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World View Theory and Science Education Research

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Fides Intellectum Quarens

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Editor's Preface

This monograph is timely for the membership of NARST. As science educators probe teaching and learning in an endeavor to make sense of learning in classrooms, there is a need for theoretical frameworks to enable new questions to be posed and a correspondingly fresh set of responses to be obtained. World view is a framework that can be applied to research on teaching and learning science and fits well with the trend towards studies that are interpretive in nature. The number of science education researchers using ethnographic techniques in science education research is increasing steadily and theories and methods that emanate from cultural anthropology are appropriate tools in efforts to unravel the social structure of science classrooms.

Cobern's review is a scholarly treatment which highlights many issues in science education that have been taken for granted. In an important sense Cobern has initiated a much needed debate that should stimulate the thinking of the science education research community. For example, Cobern's world view raises questions about alternative frameworks and conceptual change, arguably one of the most researched areas in science education in recent years. Epistemological issues are also considered in a thoughtful manner, and the world view framework provides those who have been involved with research on metaphors and beliefs a framework in which to consider and expand their work.

William Cobern is to be commended for his efforts to produce the third NARST monograph. Unlike the first two monographs, the concept of world view will be new to many NARST members, and as a consequence, should be essential reading for those with long histories in conducting research on science teaching and learning and for neophytes embarking on their first study in science education. Evidence of the impact of this monograph will be an increasing number of studies that utilize world view as an interpretive framework for their studies of science teaching and learning.

Kenneth Tobin
Chair, Publications Committee

CHAPTER 1

Introduction

I had the privilege of teaching at the University of Sokoto, Nigeria, from 1979 to 1983. In my science education courses I routinely presented my students with a moral dilemma, one that I continue to use with my American students. I asked them to imagine the following scenario:

> You are out on a lake in a boat with a spouse, a parent, and young son or daughter. Of the four in the boat you are the only one who can swim and the boat has no life preservers. Suddenly the weather turns bad. The boat flounders and all are cast into the water. You quickly realize that with the distance to shore you have hope of saving only one of your passengers, your spouse, your parent, or your child. Which one will you save?

It is a difficult decision but most of my Nigerian students came to the same answer. They would save the parent. And my American students? They too generally agreed on one answer, but it was to save the child. What is interesting is the utter astonishment each group feels at hearing the other group's response.

My what different ways we have of seeing the world!

CHAPTER 1

The Assumptions of Misconception Research

Some of the most interesting work currently being done in science education research is with what at first glance appears to be scientifically misconceived ideas about the causes and mechanisms of natural phenomena. This research which is related to a larger body of research on students' conceptual understanding (Pines & West, 1986), has come to be known more simply as misconception research. There are, however, numerous other terms used to denote basically the same phenomenon, e.g., primitive science, naive theories, alternative frameworks (Gauld, 1987). This type of research can be dated as early as the sixties (see Kuethe, 1963; Boyd, 1966); but it came into its own with the 1983 and 1987 international symposia on misconception research in science and mathematics education held at Cornell University (Helm & Novak; Novak). Researchers have demonstrated that students do not come into the science classroom with minds *tabula rasa*. Students bring to class ideas and values about the natural world that they have formulated based on their own socio-cultural environment including previous educational experiences (Hawkins, 1985; Morrison, 1985; Gunstone, 1988). As science, some of these ideas are simply incorrect, others are quite close if not essentially correct. Some students come into class already holding a high view of science, i.e., they like science and they think it is important. Others come with value and belief systems that will readily incorporate a high view of science given the proper circumstances. Others are prepared to resist. The objective of misconception research is,

> to enable us to learn more about the content of the beliefs and ideas students bring to formal instruction in the sciences. The rationale lying behind much of this work is that by coming to better understand these views we will gain more insight into certain intellectual difficulties students encounter in the course of their efforts to learn science. (Hills 1989, p.156)

In recent years science educators have studied the content of student ideas concerning many physical phenomena - a veritable *cottage industry* as Susan Carey (1986) has commented. To date misconception research, particularly in the United States, has largely been limited to elucidating misconceptions in various science subject areas. Even where more emphasis has been placed on understanding the student's point of view (e.g., UK and Australia) the research still culminates with suggestions for developing instructional strategies for replacing misconceptions with accurate scientific understanding. As G.L.C. Hills states, the researchers generally believe "that youngsters' untutored frameworks and methods stand in need of repair or replacement" (1989, p.182). Regardless of the wisdom of this focus, the

significance of misconception research is the attention given to the epistemology of students, whether they are young adults or children. This is in marked contrast to Piagetian researchers in science education who, to paraphrase Gareth B. Matthews, do not take children's puzzlings seriously (1980, p.48).

As in any avenue of research, misconception research involves assumptions. Hills in his recent critique of misconception research has unpacked some of these. He found that the research is,

> informed by the assumption that pupils' untutored ideas are scientific, if only in some embryonic sense...much of this research seems to have taken it for granted that pupils' ideas can be understood as some form of primitive or unsophisticated science. (1989, p.157)

The research assumes science to be the "proper yardstick for assessing" student views (1989, p.161). Furthermore, it can be inferred from the corpus of misconception research that often an assumption of homogeneity among students is made, even when there is gender, racial, and cultural diversity among students. Specifically, researchers assume that students come into elementary, secondary and college science classes with relatively homogeneous, fundamental views of the natural world capable of assimilating and valuing modern scientific understanding when science knowledge is presented in proper enquiry fashion. When a misconception is encountered researchers seek an exact identification of the misconception, and methods for supplanting it with accurate scientific understanding. Why? In Hills' colorful phrasing, to save the students from "the clutches of a misconception," that is, any view that "parts company with the currently accepted scientific view" (1989, p.161). The researchers do not ask:

> Is it possible that this scientifically misconceived idea is a logical deduction from some fundamental view of nature held by the student?

This question would indicate that researchers suspect more to be at issue than factors of pedagogy and student intelligence. Moreover, once this question is entertained one must reconsider the wisdom of misconception research assumptions.

CHAPTER 1

ACM: The Alternative Conceptions Movement

In the general field of misconception research there are researchers interested in students' epistemological structures *per se*.[1] Gilbert and Swift (1985, p.682) note that "an emerging 'invisible college' for what we have termed the 'alternative conceptions movement' (ACM) appears to be gradually emerging." According to Osborne and Wittrock:

> over the last few years there has been a growing awareness among science educators of the importance, for learning, of the conceptions that children of all ages bring with them to science lessons. (1983, p.489)

An important premise in ACM research and something that separates it from other misconception research is the premise that children's ideas,

> are not simply isolated ideas...but rather they are part of conceptual structures which provide a coherent and sensible understanding of the world from the child's point of view. (Gilbert et al., 1982, p.623)

While applauding the shift away from isolated views labeled misconceptions and toward the recognition that children hold integrated views representing reality, Hills argued that the ACM researchers nevertheless continue the misconception assumption that the student's view is to be judged as a scientific view. For example, though Osborne and Wittrock (1983, p.489) wrote:

> a most important feature of these studies is the attempt to establish the views children hold whether or not these views are congruent with those of scientists,

the underlying assumption is that the student views are eventually to be judged on scientific grounds. Those views found wanting are deemed in need of change. The assumptions suggest things about the researchers' own world views and indeed opens them to the charge of scientism. The line between science and scientism is crossed when one insists that validity of student views or ideas must be solely determined on scientific grounds, as if to say there are no other legitimate grounds for assessing validity. Quite the contrary, student views,

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[1]See for examples, Driver, Guesne & Tiberghein (1985); Driver & Easley (1978); Fensham (1980); Freyberg & Osborne (1981).

> provide a different sectioning of experience precisely because the pursuit of scientific knowledge is not the only or even the most important goal they subserve. (Hills & McAndrews, 1987, p.216)

From the beginning of misconception research there have been those uncomfortable with the term *misconception*, seeing it as emotive and pejorative. Some of the early researchers such as Champagne, Gunstone and Klopfer (1983, 1985) had moved away from the term by the mid eighties. One unintended result has been the proliferation of replacement terms. Abimbola (1988) has recently made a case for eliminating all of the various terms and settling with *alternative conception*. The difficulty with this position is that any use of the adjective *alternative* implies an either/or situation which is neither necessary nor prudent. Gunstone (1989), in response to Abimbola, argued that it is not possible to settle on a single term appropriate for all studies in this field. He cited the anomalous groupings of papers at the 1988 annual meeting of the National Association for Research in Science Teaching (Blosser & Helgeson) that resulted from lumping all misconception studies. Though Gunstone's position has its appeal, Hills' term *untutored beliefs* is to be preferred in most situations. This term carries no epistemological nor evaluative baggage. It simply refers to the beliefs that students acquire in their everyday experience, not as a result of formal schooling. One may also agree with Gunstone that there are other occasions when the term *misconception* is the more appropriate.[2]

Commonsense Theory and World View

Commonsense Theory

Hills' paper on student untutored beliefs is a welcome addition to the research literature because he so clearly identified these crucial assumptions in misconception and ACM research. He dismissed them and argued that many of the student views now labeled as misconceptions can be better understood as *untutored* beliefs. Hills uses the term *untutored* as a nonpejorative designation for a person's understanding of the world as gained from everyday experience in a cultural context (which may include formal instruction mediated by family or religion), as opposed to views gained through formal school instruction. These untutored beliefs are not part of an alternative framework, but of a *commonsense theory*:

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[2]See Chapter 6, Figure #14, p.95.

> it seems evident that children come to school already equipped with a more or less sophisticated understanding of how the world works...commonsense, then is the range of concepts, beliefs and values that people share which provide a basic view of the world, of their position in the world and of how they ought to act...it is more properly viewed as a system of shared beliefs or concepts which provides the basis for day-to-day activities within a culture. (Hills, 1989, p.169)[3]

The notion of commonsense theory originated with David Hawkins (1978) and was further developed by Hills and McAndrews (1987). Commonsense theories have been studied in various cultural situations (e.g., Hewson, 1985; George, 1986,1988) and indeed one would expect to find them among all people,

> the existence of the commonsense scheme (or schemes) is crucial, for on it depends the very possibility of communication and other forms of social relations. Of course, none of this is meant to suggest that commonsense is everywhere the same. (Hills, 1989, p.170)

One can thus distinguish two basic views of student untutored beliefs. There is a low view associated with the misconception and alternative conception movements, and a high view associated with the commonsense movement.

This difference in view point is reminiscent of differences in anthropology sixty years ago provoked by the 1926 publication of Lucien Levy-Bruhl's *How Natives Think*, in which he argued that the thinking of primitive peoples is prelogical and mystical. This was an inference drawn by comparing the cultures of nonmodern peoples with the cultures of modern peoples and evaluating the nonmodern peoples on modern terms. In contrast, Evans-Pritchard (1929), Max Gluckman (1944) and Robin Horton (1967), among others, have argued that traditional thinking is eminently logical, given the context in which it operates. They remind one of Boas' earlier conclusion,

> the traditional and customary beliefs of a society provide no evidence about the way individuals think. Beliefs that an outsider considers bizarre are not evidence of bizarre thinking. They tell us something about the social tradition...about pat-

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[3]For other work on commonsense theories see Bliss (1989); Bliss & Ogborn (1988); George (1986 & 88); Viega (1988). For a related research avenue see Marton (1988) on phenomenography.

> terms of thought, which are a social product. (reported by Musgrove, 1982, p.70)

In like fashion, student untutored beliefs are socio-culturally influenced constructions critical to personal meaning and socio-cultural interaction on a daily basis.[4] Given this understanding of a person's untutored view of the world it becomes inappropriate for science educators to see these views as misconceptions.

World View

Difficulties for the science educator occur when student commonsense theories appear to compete with the scientific understanding that the teacher has as his or her instructional objective. Science educators wish to understand the nature of this competition and why it is that the scientific understanding so often competes poorly. This requires an investigation of the foundational beliefs, i.e., presupposition,[5] about the world that support both commonsense and scientific theories - that is *world view*.

The theoretical work reported in this monograph differs from current interests in misconception and ACM research in that its focus is the epistemological levels antecedent to the specific views that students hold about physical phenomena, whether one calls those views commonsense theories, alternative frameworks, misconceptions, or valid science. From this theoretical point of view, each person can be seen as having a fundamental, epistemological macrostructure which forms the basis for his or her view of reality. The more common term is *world view*. Commonsense theories and scientific theories are different ways in which one makes sense of the world.[6] Both ways, however, rest on the fundamental assumptions (presuppositions) of one's world view. This relationship is illustrated with the use of Gowin's *Knowledge Vee* (1981) in Figure #1. It is not necessary, however, to view commonsense and scientific theory as being mutually exclusive alternatives as the Vee might suggest. It is more appropriate to see,

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[4]Socio-cultural is used as an inclusive term representing both social interaction and the environment of meaning and symbols in which social interaction takes place (See Geertz, 1973).

[5]For a more complete discussion of belief and presupposition see Chapter 3, pp.40&41. The terminology of assumption and presupposition is discussed in Chapter 2, pp.18-20.

[6]For an excellent account of the difference between commonsense and science theories, see Hills & McAndrews (1987).

> scientific theories and commonsense theories as being two distinctive but overlapping frameworks and as involved in activities animated by distinctive but overlapping purposes. (Hills, 1989, p.181)[7]

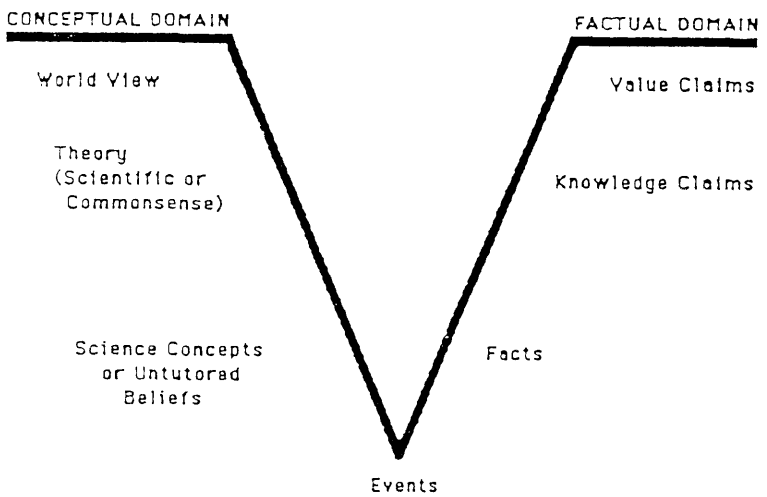

Fig. 1. Gowin's Knowledge Vee: Science and Commonsense

Figure #2 is an attempt to illustrate the probable relationship between scientific and commonsense theory within the context of world view. Both types of theory are made possible by world view presuppositions. It is likely that some of these presuppositions are shared while others are not. The spheres

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[7]According to Wolters (1989) the best English term for the German *Weltanschauung* is *worldview* as a single word. However, in American dictionaries *world view* is always two words. That is how it most often appears in the scholarly literature and how it appears in this monograph. Related concepts for world view that occasionally appear in the education literature are root metaphor, world hypothesis, view of nature, view of reality, and perceptual framework. Often these concepts are incorrectly used as synonyms for world view.

representing the theory level overlap to indicate that (in all likelihood) there are elements in common. The double pointed arrows indicate that influence is probably bidirectional. Finally, scientific theory is shown further removed from world view since it is not a result of inculturation, but of formal instruction. Of course, world views develop, evolve and change. Thus, experiences such as formal science instruction have the potential for influencing world view. As stated above, Figure #2 is a suggestion of how things are likely to be. Understanding the articulation of world view, commonsense, and scientific theory will only come with considerable research.

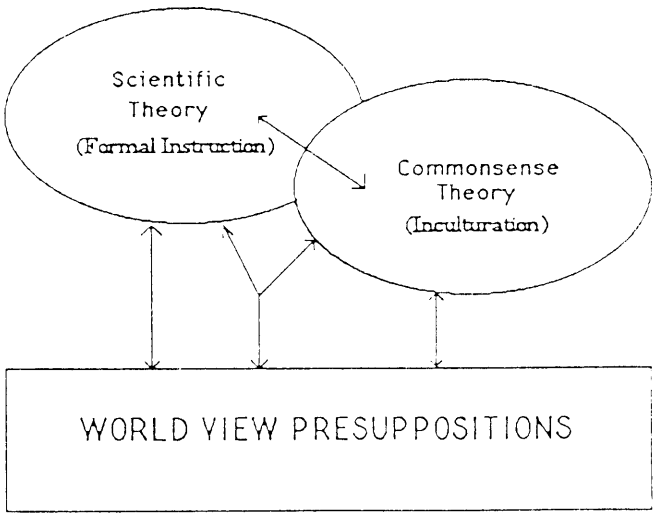

Fig. 2. Science Theory, Commonsense Theory, & World View

In a 1983 publication, Hawkins wrote about a deep barrier phenomena in learning. In doing so he touched at the heart of world view theory, presuppositions:

> The textbook says that heat flows from hot to cold, or that light travels in straight lines, or that the earth goes about the sun; the teacher tries to elucidate... But failure is often imminent. In each case, the intended communication is blocked, more often than not, by a radical mismatch between the presuppositions of the book or the teacher and those of the child. What the book and the teacher obedient to it try to communicate often presupposes (but fails to induce) a radical reorganization, in each case, of some commonsense category of experience. If our early grasp of motion is itself all *geo*graphical, then the earth itself surely does not *go*. (p.75)

To date science education research has focused on the sphere of scientific theory, which includes theory considered to be prescientific, misconceived scientific, and alternatives to scientific theory. In a discussion of barriers to scientific ideas and attitudes, barriers such as those described above, Hawkins wrote:

> reasonably patient explanation is no cure...we are up against something *rather deep* in the relation between science and common sense; we are up against a *barrier* to teaching in the didactic mode which has hardly been recognized, or if recognized has been seen mainly as a challenge to ingenuity in teaching rather than as a challenge to a deeper understanding of human learning...(1978, pp.5&7; emphases added)

Twelve years later the situation is much the same. The concerns of education are for the most part with the "domestic affairs" of science and not "foreign relations," to use Hills' apt phrasing (1989, p.183).[8]

The study of foreign relations requires a concept such as world view. World view research means seeking to know more about students' presuppositions about the world, their *epistemological macrostructures*. It is a logical extension of current research avenues although some may see world view as an issue only in conjunction with gender and culture. This tendency to assume general homogeneity amongst students, however, may be the very assumption that keeps researchers from a more comprehensive understanding

[8]There are important exceptions. Millar (1989) is a good example of a collection of articles that "explores the areas of common interest between science education and science studies" (p.1), where science studies refers to the social study of science and science education.

of factors that lead to science achievement and positive science attitudes and interest. Furthermore, world view theory should help provide the needed theoretical framework for continued commonsense theory research on a nonpejorative footing, as well as for essential research regarding gender and cultural factors in science education.

A critical hindrance to world view research has been the wont of a theory of world view that can direct analysis. The purpose of this monograph is to discuss an adaptation of the Kearney logico-structural model of world view as a theoretical framework for directing science education research with regard to student untutored beliefs, students' scientific understanding, and the development of science interest and attitude. Kearney's theory and the supporting evidence is the subject of his book, *World View* (1984). The book reviews a broad range of cultural, ethnophilosophical and world view studies in the literature of cultural anthropology, including Kearney's own research. From this review he identified common categories to form his theoretical model.[9] The very fact that Kearney's theoretical work is based on empirical anthropological research rather than on more speculative philosophical analysis gives it a credibility lacking in other approaches to world view (e.g., Pepper, 1942). Of course Kearney is not without his critics. Interested readers should consult reviews by Brown (1984), Dundes (1984), and Wilk (1985).

M.F.D. Young made an observation that is, in fact, one of the crucial reasons for raising the issue of world view in science education:

> school science separates science from pupils' everyday lives, and in particular their non-school knowledge of the natural world. It is learnt primarily as a laboratory activity, in a room full of special rules, many of which have no real necessity except in terms of the social organization of the school. (1976, p.53)

If science educators can come to a better understanding of how people view the world and why, perhaps the structure of science education can be changed so that Young's separation is closed.

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[9]For a discussion of the method of grounded theory in ethnography, see Hutchinson (1988).

CHAPTER 1

Critical Assumptions and Terminology

Philosophical Assumptions

The study of world view is itself influenced by the world view of the researcher, as the controversial work of Margaret Mead so graphically illustrates.[10] Knowing this to be true Kearney begins his account of logico-structuralism by openly declaring that his own world view is significantly informed by Marxist materialism. This influence is indeed seen in his writing, though readers will not find his world view model to be inherently Marxist. This is not surprising for several reasons. To begin with, world view is a *totality* concept referring to one's total outlook on reality. Marxism quite specifically is a political philosophy that can become resident in very different world views.[11] Kearney is a Westerner and naturally shares in much of the Western, non-Marxist tradition. In fact, his own book openly shows the considerable influence of the non-Marxist, Western anthropologist, Robert Redfield. Thus, without difficulty, one may reject the Marxist-materialist tenets in Kearney's writings, and accept his world view model as a grounded theory based on research in cultural anthropology. As to his Marxist philosophy, one may suspect that Kearney's Marxism is more important to his doing of ethnography, such as on his choice of subjects and specific research questions.

The motivating philosophy in this monograph is critical realism. This view posits ontologically real touchstones (e.g., the earth, humanity, God). World views are constructed out of the need to make sense of these touchstones. The dynamics of environment - human, social, philosophical, economic, physical, etc. - result in world view variations (see Figure 3, p.23). Those variations, however, are finite, being circumscribed by the touchstones of ontological reality. Whether this monograph would have been significantly different had it been written by a radical constructivist, for example, is debatable. From either philosophical stance, the researcher will use world view theory in the study of student cognitive culture, science classroom culture, and the interaction of the two. As with Kearney's Marxism, differences surface at other levels. In science education, critical realists and

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[10]See page 59, footnote #14. For a second example of controversy, see Jones (1972).

[11]The relationship of philosophy to world view is discussed in Chapter 2, pp.18-20.

radical contructivists are more likely to part company over matters of curriculum and policy.[12]

Pedagogical Assumptions

Most would grant that in ethnically diverse classrooms a **prima facie** case can be made for world view variations as a factor in the education process. The principal, pedagogical assumptions of this monograph are that the students have subtle, world view variations; that these world view variations support valid views or theories about the world that may or may not be scientifically oriented; and that these variations constitute an important factor in science achievement and attitude development among students. This monograph differs from much of the literature in science education research in that studies in anthropology are incorporated as research just as important to science education as studies in the history and philosophy of science.

And finally, the more general term *science education* is used rather than the more specific term *science achievement.* This is based on the position that *attitude* and *interest* have cognitive roots, and thus are shaped by world view presuppositions. The term *science education* incorporates achievement, interest and attitude. At this early point in the development of world view research in science education it is advisable that one use the more specific terms carefully.

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[12]For further discussion of radical constructivism and critical realism, see Chapter 2, pp. 25-29.

CHAPTER 2

World View by Definition...

According to Webster the definition of world view is *Weltanschauung*, but then the real world is seldomly as simple as a dictionary definition.

Lebenswelt, Weltbild, and Weltanschauung

The English word *worldview* is a claque on the German word *Weltanschauung*.[1] The first published appearance of *Weltanschauung* is in Kant's *Critique of Judgement*, 1790, and one may assume that he coined the term. Kant quite simply used it as a reference to one's sense perception of the world round about. One of Kant's students, Johann Fichte (1762-1814), brought the term from Konigsberg to Jena where it was adopted by Fichte's colleague, Friedrick von Schelling (1775-1834). With Fichte and Schelling the meaning of the term began to change. It no longer referred to simple sense

[1]For this section on the history of the term *Weltanschauung* I am very much in the debt of Prof. Al Wolters of Redeemer College, Canada (see Wolters, 1989).

perception but to intellectual perception. It referred no longer to how one sees the world, but to how one understands the world.

Fichte and Schelling were prominent early figures in the German traditions of Idealism and Romanticism that dominated German culture through the 19th Century. Thus, between 1799 and 1814, *Weltanschauung* appeard increasingly in the vocabulary of the German speaking literati, including Hegel and Goethe. By the mid 1800's it could be found in the works of historians, composers, theologians, and scientists (e.g., Leopold von Ranke, Richard Wagner, Ludwig Feuerbach, and Alexander von Humbolt, respectively). In the first decade of the 20th Century new books appearred on the *Weltanschauung* of Kant, Darwin, Nietzsche, and modern physics, to name only a few subjects. In 1904, provoked by its widespread popularity in German speaking culture, Herman Bavinck referred to it as "the slogan of the day" (quoted in Wolters, 1989, p.3). Claques on the German *Weltanschauung* quickly appeared in most other European languages and remain yet, prompting Wolters' comment "it seems that modern Western thought cannot do without the concept" (p.5).

After the turn of the century the philosophical sense of *Weltanschauung* steadied somewhat. According to Wolters, *Weltanschauung* is,

> an overall conception of reality and human existence rooted in the existential experiences of life...(p.6) ...a general concept of a deeply existential philosophical or religious totality-view...(p.8) ...a comprehensive view of life and the world which is the proper goal of philosophy...(pp.23&24)

Later in the 20th Century one finds this totality sense of the term communicated in science related literature such as Julian Huxley's *Evolutionary Vision* and Fritjof Capra's *The Turning Point*. It is also found in the writings of Christian philosopher-theologians such as Alvin Plantinga (1984) and Arthur Holmes (1983). A similar usage, but from quite a different context, can be found in *Soviet Education* articles on the development of the communist and materialist man.[2]

Dispite the philosophical emphasis of *Weltanschauung*, there continued to be related conceptions of world view. Wolters identified three totality-formations in the work of Harald Hoffding (1843-1931), life-view, world view, and religion. Life-view or *Lebensanschauung* is an involuntary, socio-culturally

[2]An especially informative article is Ogorodnikov's "Instilling the Communist World View," (1980).

determined view of the world that becomes a world view, *Weltanschauung*, when supported by arguments and claiming universal validity. This sense of world view includes metaphysics and cosmology. World view becomes religion when it informs ultimate values. Wilhelm Dilthey (1833-1911) expressed a similar tripartite view which is of interest because of its later association with anthropology. He argued that one has a pretheoretical, implicit world picture or *Weltbild* that naturally develops in the context of one's *Lebenswelt*, i.e., the world in which one lives (Holmes, 1983). Dilthey further theorized that on the foundation of one's *Weltbild*, a person systematically constructs a *Weltanschauung* to explain the vagaries and mysteries of life:

> the mystery that surrounds the great crises of birth and death, the round of the seasons and the crops, the endless battle of human freedom against natural forces and necessities...From the most primitive societies upward, men busy themselves to read this riddle...and systematic *Weltanschauungen* are deliberately worked out, where...a full interpretation of the universe is set forth. (1957, pp.25-27)

Dilthey's work exerted great influence on scholars including Franz Boas (1858-1942). Boaz immigrated to the United States from Germany bringing with him the notion of *Weltanschauung* (Kearney, 1984). However, Boas steered American anthropology in a different direction. He opposed the cultural evolutionists of his day who sought an overall theory of cultural development.[3] Instead, he encouraged his own students to undertake the exhaustive study of individual cultures for the purpose of reconstructing individual cultural histories. Ruth Benedict is perhaps his most renown student. Her book *Patterns of Culture* provides one of the earliest and best American examples of the anthropological study of world view. Benedict's goal was to construct a society's *Weltbild* by integrating observed social behavior into patterns or configurations.[4]

Boaz is an especially fascinating figure because he was a student of the natural sciences. He was also interested in the history of cultures though not a formal discipline at the time. He pursued advanced studies in physics and geography at Heidelberg and Bonn, and later at Keil he received his

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[3]Though Boaz opposed the determinism of Dilthey, out of a regard for scholarship he encouraged his students to study Dilthey's theories. See Ketner (1972, p.7) and Mead (1959, p.211).

[4]The configuration (or pattern) approach to world view is discussed in the next section.

doctoral degree. It was while doing research in physics that Boas became interested in problems related to the processes of inquiry:

> After becoming aware of the large subjective factor involved in his laboratory observations he realized the necessity of taking into account the situational conditions...This problem evolved into a broader project concerning the influence of environmental conditions on perception in general. (Kearney, 1984, p.26)

What is so interesting about Boas is that at the turn of the century he was intrigued by an issue that is increasingly becoming of interest in the late 1900's, i.e., the impact on science of the socio-cultural environment.[5]

At this point one should note a distinction between two uses of the English term *world view*. There is the more philosophical usage related to the German *Weltanschauung*. There is also the sense of world view as a life-view or world picture, related to the German *Weltbild*, identified with Boas school of cultural history. It would help if one could reduce the semantic confusion associated with world view as *Weltbild*, the cultural term, and world view as *Weltanschauung*, the philosophical term. For this purpose, the American philosopher John Kok (1988) coined the English terms *lived* world view and *articulated* world view. Lived world view refers to Dilthey's *Weltbild*, the meaning of world view as it is generally used in anthropology. Lived world view conveys the sense that a world view is a communally shared, epistemological framework essential for daily life. An articulated world view, quite opposite of a lived world view, is formed in a process that is "conscious, coherent [and] unambiguous" (Kok, p.20), and is much more closely related to philosophy, religion, and ideology. Plato's dialogues, Aristotle's treatises, Calvin's *Institutes* each sets forth an articulated world view. Of critical importance to educators is how the facets of a *lived* world view are related to *articulated* world views. Both are important parts of the cognitive and perceptual framework depicted in Figure #3 (p. 22). In any given cultural setting, the distinction between the two is often obscured, provoking endless headaches among scholars. These two aspects of world view were the cause of heated discussion among anthropologists at the 1968 Wenner-Gren conference on world views. No resolution was reached then, nor since (Jones, 1972). An elucidation of the dialectical relationship between these two levels of world view will be an important issue in science education research, though not a simple one. Of central interest to science educators is the notion of a scientific world view which in its common usage refers to an

[5]For further information on the life and work of Franz Boas, see Stocking (1974).

articulated world view (see AAAS, 1989).[6] Many intriguing questions come quickly to mind. For example, can there be more than one scientific, articulated world view based on a scientifically compatible, lived world view?

Defining the Concept of World View

As noted above, the concepts of lived and articulated world view are frequently comingled. It is thus no surprise that religions and philosophies are often seen as world views. For example, people speak of a Christian world view or an Islamic world view, a constructivist world view, or a realist world view. Indeed, religion can be a powerful tool used by reflective individuals for articulating a religiously informed world view. Futhermore, religion is an especially powerful formative force on the mind of a growing child, greatly influencing the contours of a child's developing world view. There are however, many environmental factors that influence children and adults. Though religion influences world view, religion itself is influenced by world view. Consider, for example, both the significant differences and similarities between African and Western Christians, between Arabian and non Arabian Muslims.

Concerning philosophy the distinction is more clear. Philosophy by definition is a conscious, self-reflective endeavor. The premises of philosophy are arrived at through critical thought. Quite the opposite, the assumptions of world view are *implicit*, and only by the greatest effort at self-reflection does one become aware of them. Generally speaking, world view is not a matter of personal choice.[7] Wallace descriptively summarized the relationship of religion and philosophy with world view:

> ...a world view is not merely a philosophical by-product of each culture, like a shadow, but the very skeleton of concrete cognitive assumptions on which the flesh of customary behavior is hung. World view, accordingly, may be expressed, more or less systematically, in cosmology, philosophy, ethics, religious ritual, scientific belief, and so on, but it is implicit in almost every act. (1970, p.143)

Or to paraphrase Hiebert (1976), religion and philosophy are visible expressions of a world view.

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[6]The concept of a scientific world view is discussed in Chapter 5.

[7]For a much more complete analysis of the relationship between world view and philosophy, see Board (1963) and Kemer (1972).

World View by Definition ...

World view, as used in anthropology, refers to the culturally-dependent, *implicit*, fundamental organization of the mind. This implicit organization is composed of presuppositions or assumptions which predispose one to feel, think, and act in predictable patterns.[8] Kearney refers to world view as:

> ...culturally organized macrothought: those dynamically inter-related basic assumptions of a people that determine much of their behavior and decision making, as well as organizing much of their body of symbolic creations...and ethnophilosophy in general. (1984, p.1)

World view undergirds rationality. To be rational means to think and act with reason, or in other words to have an explanation or justification for thought and action. Such explanations and justifications ultimately rest upon one's presuppositions about the world. In other words, a world view inclines one to a particular way of thinking. According to Kearney a world view:

> ...consists of basic assumptions and images that provide a more or less coherent, though not necessarily accurate, way of thinking about the world. (1984, p.41)

A world view defines the self. It sets the boundaries of who and what *I am*. It also defines everything that is *not me*, including my relationships to the human and non-human environments. It shapes one's view of the universe, one's conception of time and of space. It influences one's norms and values (Kraft, 1978, p.4).

A world view has five functions. It explains the how and why of things, and why things continue as they do. It validates "goals, institutions, and values of a society and provides them with a means for evaluating all outside influences as well as activities and attitudes within the society" (Kraft, 1974, p.4). A world view reinforces people "at points of anxiety or crisis in life providing security and support for the behavior of the group" (1974, p.5);

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[8]To this point two terms have been used in reference to the content of a world view, *assumptions* and *presuppositions*. *Assumption* is Kearney's (1984) preferred term while *presupposition* is shortened from Collingwood's (1940) *absolute presupposition*. Because it is generally necessary to use the term *assumption* for other purposes, e.g., research assumptions in an investigation, it is less confusing to use the term *presupposition* when referring to world view content. For the sake of brevity, the adjective *absolute* has been dropped though Collingwood's distinction between absolute and relative presuppositions is an important one.

and both encourages and prescribes behavior. A world view is an integrator. It allows one to order and systematize sense perception. According to Kraft:

> this system makes it possible for a people to conceptualize what reality should be like and to understand and interpret all that happens day by day in this framework. (1974, p.5)

Finally, there is an adaptive function. A world view is "resilient and reconciles differences between the old understandings and the new in order to maintain a state of equilibrium" (1974, p.5). World view helps one maintain a sense of mental order and balance in a world of change via the dialectical interaction between our extant world view presuppositions and environmental changes.

Cultural anthropologists study world views to learn more about people and their cultures. They want to know why one group acts and thinks this way, while another group acts and thinks a different way. For educators the importance of world view is identified in two assumptions:

> that the best immediate understanding of behavior is offered by understanding the thoughts that underlie the behavior, and...other things being equal, the economy of human thought and the nature of culture are such that cognitive assumptions at work in one area of life, say economic production, will also organize thinking in others, say...ideas about human nature. (Kearney, 1984, pp.3&4)

In other words, one assumes that thought has a great influence on action; and furthermore, that even very different areas of thought are influenced by what might be called generic, cognitive presuppositions. In a discussion of conceptual change, Carey wrote:

> we must find better ways of *representing* conceptual structures so as to be able to analyze conceptual reorganization. (1986, p.1129, emphasis her's)

Knowing more about students' world views should help researchers come to a better understanding of conceptual change by providing a more complete understanding of conceptual structure. It should as well enable educators to better understand student attitudes and achievement in general.

The Formation of a World View

The driving force behind the development of a world view is a person's need to relate to the outside world. As aptly stated by Ross (1962, p.x), man's "experience is useless unless interpreted." Beginning in childhood, each person interacts with his or her physical and social environment, and through this myriad of environmental interactions, world view presuppositions are unconsciously constructed. The process occurs over a long period of time, with the formative, childhood years being of most importance. Through the years of schooling, formal education contributes to world view development; and in turn, a world view provides a foundation upon which cognitive frameworks are built during the learning process.

Ordinary experiences of maturation indicate that at some point of maturity (e.g., as an adult) the malleableness of a world view begins to decrease. It becomes resilient in the face of change providing an adult with cognitive stability. As noted above, world views also have an adaptive function which allows even adults to adjust to new environments. Thus, while world view presuppositions are strongly held, they are not immutable. The strength with which a mature world view is held appears to be inversely related to the degree of heterogeneity in a culture. The more heterogeneity, the less strongly a world view is apt to be held. This proposed process of world view development and change is what Kearney calls "dialectical constructionism" (1984, p.3). It has a compelling ring to it because it shares much with Piaget's genetic epistemology (1971) as well as with Ausubel's constructionist theory of learning (Ausubel, Novak & Hanesian, 1978; Gunstone, 1988). In human mental architecture, world view is the foundation upon which one constructs cognitive and perceptual frameworks.

Figure #3 is an attempt to illustrate the theoretical relationship that world view has with cognition, learning, perception and behavior, and environment. Within each block of concepts there are arrows indicating relationships, e.g., between world view and cognitive frameworks. Between blocks the clockwise arrows indicate relationships between sets of concepts **A**, **B**, and **C**. For example, world view directs general behavior. Our general behavior involves both sampling (or selecting) and modifying our environment, which in turn stimulates the development, modification, and evolution of our world view. Of course, to this description of world view development one must append the *caveat emptor*, "or so it appears," for little is actually known about such processes. It is reasonable however, to say that world view development must be a specific kind of the cognitive, conceptual development typically of interest to science educators.

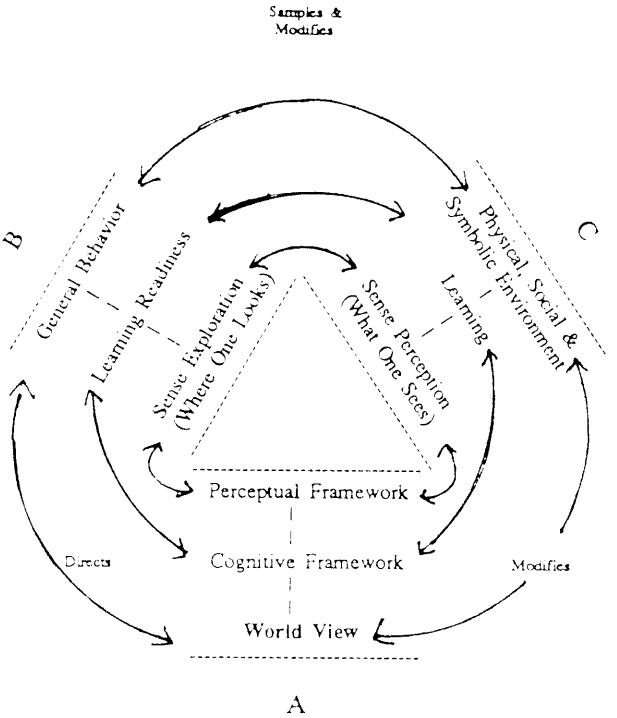

Fig. 3. The Dialectical Development and Evolution of a World View

(adapted from Kearney, 1984, p.45)

Furthermore, with respect to young children, world view development is probably indistinguishable from other aspects of conceptual development. World view theory supports those researchers interested in the *contexts of meaning* in which children construct knowledge (Bloom, In Press). These researchers opine:

> children's...understanding of their world is far more complex than what most research leads us to believe. (Bloom, p.15)

They say that it is not a simple matter of constructing propositions. Rather,

> children's thinking is guided by an ever-changing variety of knowledge, frameworks of belief, mental processes, and emotions. (Bloom, 1989)

In the literature *anthropocentrism*, *anthropomorphism*, and *zoomorphism* have all been given as examples of children's frameworks of belief (e.g., Gauld, 1987). Science educators will likely find that these types of belief in children adumbrate world view presuppositions to come. In childhood, however, it would be a mistake to see world view as a distinct conceptual development.

The *contexts of meaning* research is fairly new. Lev Vygotsky's work represents an older view of cognitive development, though one enjoying renewed popularity (Vygotsky, 1962). Vygotsky "outlined a theory of mind in socio-cultural context" (Wertsch 1988, p.82), arguing that one must consider socio-cultural history in order to understand cognitive development on the premise that:

> uniquely human, mental functioning in an individual has social origins and a *quasi-social* nature. (Wertsch, 1988, p.85)

Implicit in Vygotsky's work is the importance of contexts of meaning, including world view, to learning.[9] It is Vygotsky's emphasis on socio-cultural context that coincides with world view and context of meaning research; and pulling these three strands together should help educators further the understanding of childrens' cognitive development.

The Social Construction of Knowledge

To some extent these elements are pulled together by Joan Solomon in her work on the social construction of knowledge (1987, 85, 85b). Solomon uses a constructivist framework in her research (based on Driver & Easley, 1978). However, she objects to the personal constructivist position with it focus "firmly upon personal experience and personal knowledge" (1987, p.65). Researchers taking a personalist position contend that learning more and more about student alternative frameworks will enable educators to develop more effective science instruction strategies. Solomon argues that empirical studies have not supported this position (e.g., Gilbert & Watts, 1983).

Instead of personal construction, Solomon speaks of the social construction of knowledge. She views teaching and leaning from a sociology

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[9]For further information regarding Lev Vygotsky see Holowinsky (1987) and Simon (1988).

of knowledge perspective based on Mead (1934), Berger & Luckmann (1967), and Schutz & Luckmann (1973). A sociological view of children's knowledge,

> starts out not from the logical processes of which science boasts, but from the 'common sense' attitude that relies on being able to interchange perspectives and meanings with others. (1987, p.66)

The interchange of perspectives and meanings with others that Solomon speaks of is the socialization process into "life world knowledge" (p.67), a concept which is very close to, if not synonymous with, world view. Every thing that a student knows is embedded in life world knowledge. Solomon's crucial observation is that socialization into life is very different from the socialization into school science. This perspective has led her to investigations of social processes in science classrooms and the influence of these processes on the learning of science (e.g., 1984).

The social processes of interest to Solomon are the shared conversation of students, student interpersonal communications. Solomon has noted, however, that there are other types of social influence,

> which act more remotely on individuals through the language they use, through the unspoken expectations of their culture, or through the information media to which they are exposed. This cluster of influences is social both in the most obvious sense of acting through the larger cultural group, and also in many of the ways in which it operates. (1987, p.73).

As examples she has cited several cross-cultural investigations of specific science topics (Mori et al., 1976; Duit, 1981; Sutton, 1980; Ross & Sutton, 1982), and a review article on informal education (Lucas, 1983). Solomon concluded her 1987 paper by noting that social influences are both tenacious and pervasive, and that students are,

> strongly social beings for whom the teaching of a rigidly insulated science which makes no contact with the everyday context is simply not an option. (p.79)

The concept of social influences in science education which Solomon has so ably addressed, is critical in world view theory. World view refers to cognitive macrostructure. It refers to one's most fundamental beliefs about the world. However, as noted by Solomon, educational researchers tend to be *de jure* isolationists who consider development and learning, including world view,

to be primarily based on "personal experience and personal knowledge" (p.65). Quite to the contrary, Solomon's research has revealed the a social nature in learning; and she would no doubt concur, that world view macrostructure is also socio-culturally dependent. World view comes by way of one's socialization into life. Solomon acknowledged the crucial role of individual responsibility, yet wrote:

> it is also true that belief in our own ideas is astonishingly hard to form or to maintain without the collaboration of others. (1987, p.63)

Thus, any discussion of world view must recognize two interlocking realities. The first is that world view refers to cognition. The second is that world view is culturally and socially grounded and maintained. The research question of world view identification or description should never be raised without concomitantly raising the questions of cultural and social context. Indeed, it is contextual variety that leads to different world views, to multiple realities.

Multiple Realities

It almost goes without saying that the concept of world view has no commonsense counterpart, anymore than do the models one calls photons or genes. Any world view model is an abstraction derived from certain observed phenomena, but not a picture of those phenomena. To study world view is thus, to take an ideational (as opposed to a materialistic) approach to cultural studies. Those who take this approach are called *cognitive ethnographers* (Fetterman, 1989). Indeed, Kearney's principal assumption in logico-structuralism is that all human activity, even affection, proceeds from cognitive roots. This philosophical idealism has led many researchers to speak of *multiple realities*. As noted in the preceding section, there is much contextual variety. People live in community and in relatively circumscribed geographical locations, but there are many communities and many locations. People live in different cognitive, social, economic, and physical environments. A world view is a response to the *particular* environment in which a people live. Different environments lead to different ideas about the world, i.e., world views.

Some scholars prefer to say that the existence of different world views, means in fact that there are different worlds or different realities. They would say that reality is what one makes it to be. This inference is important to the interpretative school of research in education:

> The interpretative [school] embraces a type of philosophical idealism in believing that the mind creates reality and that an objective world separate from the perceptions of the person cannot be known. (Smith, 1987, p.176)

Interpretative researchers in science education[10] appeal to the radical constructivist philosophy of Ernst von Glasersfeld, who in paraphrase of Giambattista Vico, wrote:

> God alone can know the *real* world ... In contrast, the human knower can know only what the human knower has constructed. (1989, p.123)

Thus radical constructivism,

> discards the notion that knowledge could or should be a representation of an observer-independent world-in-itself and replaces it with the demand that the conceptual constructs we call knowledge be *viable* in the experiential world of the knowing subject (1989, p.122).

Interpretations of experience are all that one can know. One accepts the validity of interpretations in so far as they are pragmatically viable.

These ideas bear a striking resemblance to the literary theory of deconstruction:

> An old parable says that the hare was the fastest runner of God's creatures, until he began to wonder *how* he ran. Similarly, you are a natural deconstructionist if you have ever...in the middle of a conversation, realized that you were having a conversation, and that part of your mind was scripting your role. Such moments...we ordinarily suppress as bothersome interruptions. But what - asks the deconstructionist - if these moments of vertiginous self-awareness are actually the *reality* of our life in language (McConnell, 1990, p.106)?

A central tenet of deconstruction is the denial that "meaning can always be grasped in the form of some proper, self-identical concept" (p. 106). Meaning lies not in the referent of words, but in the words themselves. Similarly, the

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[10]See for example, Tobin, Kahle, & Fraser (1990).

radical constructivist does not find that reality can be grasped in the form of proper, self-identical concepts. Rather, reality for the individual is personally constructed knowledge based on and validated by experience. In both deconstruction and radical constructivism, reality is one's thinking about the world, not the world itself.

This agnostic view of reality held by radical constructivists is rooted in subjectivist views of what one can know about reality. Such views range from the moderate position taken by Kuhn in *The Structure of Scientific Revolutions* to the extremism of Feyerabend's *Against Method.* In radical constructivism, the centrality of ontological reality gives way to epistemological reality. This does offer certain epistemological advantages. Radical constructivism obviates the perennial question plaguing realism, how can one verify knowledge of reality? The constructivist accomplishes this by declaring the question unimportant. One then changes the subject to the process of constructing and *validating* knowledge, where validity refers to *viability* (von Glasersfeld, 1989, p.122). Furthermore, the constructivist, using the notion of viability, has little difficulty accounting for the large number of world views that exist among people. This much has its appeal, though the science educator will not find that radical constructivism is without problems.

Radical constructivism, and other radical forms of idealism, immediately come into conflict with commonsense. It is a situation reminiscent of Samuel Johnson's reaction to Berkeley's philosophy of immaterialism:

> The good Dr. Johnson and James Boswell were walking down a London street one day discussing George Berkeley's philosophy of immaterialism. Dr. Johnson, unconvinced by Berkeley's logic, said to Boswell, "I refute it thus!" Upon which he turned and soundly kicked the street curb with his big toe - much to Boswell's amusement!

Along with Boswell one may also be amused, but of course, Samuel Johnson's refutation of immaterialism was no philosophical threat to Berkeley. What Johnson did was to dramatically and humorously present the wisdom of common folk and everyday, ordinary life. In the everyday view of things, it is only one step further to say that not only is the world real, it is also knowable. An objective, knowable reality is very much apart of the Western world view. In the mainstream of Western tradition, scholars have assumed that knowledge is based on and circumscribed by an ontological reality; and that the validity of knowledge is determined by its correspondence with reality. Scholars have argued that the centrality of ontological reality in Western culture stems from a voluntaristic theology with its concomitant view of an objective, created world. This was a gradual, but significant Medieval

divergence from ancient Greek idealism (Foster, 1934; Klaaren, 1977; Oakley, 1961). The point of this is, commonsense rooted in world view is a powerful force. Many scholars in esoteric fields find radical constructivism to be a tenable position, a profitable one for research. Regardless of its merits, however, it must be realized that in the larger field of practicing educators, radical constructivism and extreme concepts of multiple realities will face formidable, culturally-sanctioned opposition.

The promotion of radical constructivism runs counter not only to what most students and teachers believe about the world, but also counter to what most scientists believe (Ratzsch, 1986). One might say that coming to science from within Western culture, the default position is critical realism. For critical realists the importance of ideas is that they are attempts at understanding an ontologically real world (Hart, 1984; Peacocke, 1984).[11] As alluded to above, the difficulty with realism and what has motivated subjectivism, is the uncertainty of knowledge. Knowledge changes, so how can one ever be sure that what is known is really the *truth* about the world? Critical realists recognize the importance of this question and thus there are numerous discussions of verification and corroboration (Brown, 1987; Hodson, 1982a&b).

Of course, commitment to realism stems not from its difficulties, but from its advantages. For a realist, science is an effort to *understand* natural phenomenon, not merely explain (Martin, 1972). Radical constructivism and the notion of viability reduces science to a pragmatic program for gaining control of natural phenomenon, true understanding inherently unattainable. The desire to understand what the world is really like, however, is the force that drives progress:

> it was precisely because Galileo took a *realist* interpretation of Copernican theory, and set about solving the problems it created, that progress was made. Realism provides the incentive for the development of better theories and better instruments for observation. (Hodson, 1982b, p.23)

These are indeed, weighty philosophical issues that one cannot forever dodge. As the first section of this chapter clearly indicated, world view is a philosophical concept. And though the relative merits of realism and radical constructivism are debatable, in time the issues of ontology and epistemology

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[11]References to *realism* are always references to *critical* realism where the problems of perception and verification are recognized. Typically references to realism in the interpretive literature are to *naive* realism (e.g., Briscoe et al., 1990).

that these philosophies raise must be more adequately addressed. However, discussions of ontology in conjunction with world view tend to obscure the fact that philosophy is neither the same as, nor analogous to, world view. For now, one may take to heart Jacobs' comment that "philosophers' definitions and discussions need not detain an anthropologist" (1964, p.366), nor for that matter an educational cognitive ethnographer.

CHAPTER 3

World View Theory

This chapter introduces the logico-structural model of world view. To begin with however, a review of existing world view research in the science education literature is provided as a background against which to contrast logico-structuralism.

World View in the Science Education Research Literature

World view or the related *view of the world* actually appears quite often in the education literature. The **ERIC/CLJE** indexes list hundreds of documents containing the term. As Wolters said, it appears to be a term we cannot do without. Yet for all its use world view is seldomly defined in any depth let alone developed within a theoretical context. Neither are there many substantial world view investigations. The infrequency of world view research in education stems from two difficulties, the first of which is presbyopia.

There is an ancient Chinese proverb that roughly translates, "If you want to know about the sea, don't bother asking the fish." World view is the sea in which people swim. Because of its intimate proximity, because a person perceives everything through it, world view itself is virtually invisible. An American unaware of his or her unique American world view. A scientist or science educator is unaware of the culture of science. Further, the observations of events in a culture of a different world view (e.g., the taking of standardized tests, participation in the Eucharist, or Fulani initiation rites) are seen through the lenses of one's own world view and judged accordingly. Awareness of other world views begins however, the instant one steps out of his own culture and into another (see e.g., Dugan, 1987). Ordinarily the duration of a handshake is of no conscious concern, for example, nor is the appropriateness of a greeting. In a different cultural one suddenly finds that many of the implicitly held rules of conduct no longer work. Thus it is, that in the literature of science education the most frequent use of world view and related concepts is by those struggling with the problems of developing science education in societies where modern science is not an aspect of indigenous culture (e.g., Lutterodt, 1980; Cobern, 1983; Hewson & Hamlyn, 1985).

To some extent educators have responded to the issue of subcultures within American society. In the 1980's science educators sought to recast traditional science curricula in a new *social oriented* mold, bringing about the Science, Technology, and Society movement (Patrick & Remy, 1985; Bybee, 1987). Though there is much to recommend the STS movement, one must recognize that the frame of reference has not changed. The curriculum developers see the world though the same world view. This is instantly recognizable by someone from without. For example, M. Ogawa who views science from a Japanese perspective, argued that the term *society* should be replaced by the term *culture*,

> because...science has evolved from the western *culture* and... should, therefore be seen not in terms of science-society, but a science-culture perspective. (1986, p.114)

The distinction between society and culture is crucial. According to anthropologist Clifford Geertz, culture is "an ordered system of meaning and of symbols, in terms of which social interaction takes place." Whereas, society refers to "the pattern of social interaction itself" (1973). The non-westerner is immediately aware of a tension because the system of meaning and symbols in science is not the same as the system in his or her traditional culture. Thus, education in science is a cross-cultural issue.

Ogawa argued that the specific issues for resolution between traditional, non-western culture and the culture of science are, view of man

and nature, and ways of thinking (p.116). These are very much world view issues and have been picked up again and again by researchers doing cross-cultural work from Nepal to Jordan, to Nigeria, to Papua New Guinea, to Navajo reservations (e.g., Dart & Pradhan, 1967; Dart, 1971; Nduka, 1974; Maddock, 1975a&b; Bajah, 1981; Hewson & Hamlyn, 1985; Jegede & Okebukola, 1988a).

The cross-cultural work of M.B. Ogunniyi is a good example. He has written a series of thoughtful papers each dealing with some aspect of the relationship between scientific and traditional African world views (1983, 84, 85, 88). Though he has never defined the term, nor provided a theoretical model of world view, he implies that a world view involves presuppositions about specific aspects of the world. According to Ogunniyi, the world of an African is monistic/vitalistic while that of the modern scientist is irrational/impersonal. Cause and effect for an African is teleological, but mechanistic for a scientist. Okebukola and Jegede agree:

> causality is seen in terms of volition and not in terms of mechanistic laws. Things do not 'just happen' in the traditional African society; events have a cause, but that cause is seen in personal terms. (1988, p.3)

With respect to the nature of being, Odhiambo wrote:

> The thread that constantly runs through the African's worldview is one of life, or force, or vital-force. All beings - whether human, animal, plant, or inanimate -possess vital-force of their own. (1972, p.43)

There is no presbyopia here because of the stark contrast between a traditional African world view and the way in which modern science views Man, nature, and causality.[1] However, in the Western world where modern science had its birth, science is so much apart of the visible, national cultures that many Westerners fail to see science as a cultural artifact. Americans often fail to understand that there exist American subcultures that on occasion experience the same type of tensions that traditional, non-western peoples experience. For example, in the feminist literature it has been noted that the impersonal, formal view of nature prominent in science can conflict with the more personal, informal orientation of many women (Halpin, 1989; Whatley, 1989).

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[1]For an enlightening discussion of the African world view see Temples (1959); Jahn (1961); Odhiambo (1972); Idowu (1973). Also the novels Chinua Achebe and Cheikh Hamidou Kane can help provide a vicarious understanding of cultural tension and conflict.

For another example, the mechanistic explanations of science have the potential for conflict with the teleological view of life held by orthodox Christians (Newbigin, 1986).

The second difficulty inhibiting the use of world view concepts is inadequacy of definition. As interesting and significant as is the work of Ogunniyi, Okebukola and others, none of these researchers has offered an analytical, operational definition of world view, let alone a coherent, articulated model. For the most part, neither have Western researchers.[2] People who use the term world view tend not define it, or define it only vaguely:

> one's view of the world
> our understanding of man and nature
> our type of thinking
> how we understand cause and effect

In the literature of anthropology and philosophy, W.T. Jones (1972) found thirteen different synonyms for world view, commenting that:

> Critics suspect that a concept so variously named is itself somewhat vague, and this suspicion doubtless explains why some students of culture prefer to ignore the notion of world view altogether...(p.79).

When Ninian Smart (1982) referred to world view as a synonym for religion and ideology, including secular ideology, he identified the sense of the term as most people outside of anthropology use it. The result of this ambiguity of definition is that many researchers fail to see how world view can be a useful concept in science education research. In 1974, Brent Kilbourn pioneered the use of world view in empirical science education research. In 1984, he wrote a second article in which he summarized his earlier work. However, with the exception of a 1988 paper by Proper, Wideen and Ivany, there has been no further empirical education research where world view is involved as a key concept.

The Root Metaphor Approach to World View Research

Kilbourn's work is worthy of study. He noted Roberts' comment that "virtually every science teaching program tries to get youngsters to adopt a scientific way-to-explain" (Roberts, 1972, p.1). He understood this to be a

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[2]These remarks thus are not a criticism of non-western researchers. On the contrary, they are to be commended for their good vision.

world view issue. He also understood the tremendous complexity of world view and the inadequacy of typical definitions (Kilbourn, 1984, p.36). Kilbourn, recognizing that world view in the *hidden curriculum* is unavoidable, investigated world view as implicitly projected by secondary biology textbooks. In Stephen C. Pepper's philosophical treatment of world view published in a book titled *World Hypotheses* (1942), Kilbourn found an analytical tool which he felt solved the problem of ambiguity.[3]

Pepper's argument is that individuals draw inferences or hypotheses from the myriad of daily experience. From this one derives meaning and explanation. To the extent that any of these hypotheses lack scope and precision, they are less than ideal. According to Pepper, an ideal hypothesis "is one that all facts will corroborate, a hypothesis of unlimited scope. Such a hypothesis is a world hypothesis" (p.77). World hypotheses can be identified by *root metaphor theory*:

> A man desiring to understand the world looks about for a clue to its comprehension. He pitches upon some area of commonsense fact and tries if he cannot understand other areas in terms of this one. This original area becomes then his basic analogy or root metaphor. He describes as best he can the characteristics of this area, or, if you will, discriminates its structure. A list of its structural characteristics becomes his basic concepts of explanation and description. (1942, p.91)

According to Pepper, "a world hypothesis is determined by its root metaphor" (p.96). He concluded that there are six possible world hypotheses by identifying six root metaphors. Two, animism and mysticism, he deemed inadequate based on lack of scope and precision. The four adequate metaphors are: formism, mechanism, contextualism, and organicism. As explained in the literature:

> Formism is preoccupied with the form of things, with the similarity of this or these instances to an idealized form. Taxonomic botany is a perfect example... (Roberts, 1982, p.279)

> Mechanistic thinking, which derives its name from mechanics, is called the thinking of the experimental scientist (Harris et

[3]For other examples of research employing Pepper's root metaphor theory see Harris et al. (1977); Morris & Hursh (1979); Germer et al. (1982); Roberts (1982); Johnson (1987).

> al., 1977, p.538). Formistic thinking shades into mechanistic thinking when one asks after the causes, the influences, or even the correlates...(Roberts, 1982, p.279)
>
> Organistic thinking has been called systems thinking, pattern thinking...Rather than focusing on single elements or linear relationships, the organistic thinker sees the world in terms of complex constellations or patterns with an implicit order ...(Harris et al., 1977, p.538)
>
> Contextualism is a system of thought that focuses on the event in its context. We have no adequate knowledge of an event...until we know the context in which it occurs... (Roberts, 1982, p.279)

Though none of the researchers using Pepper's theory have mentioned it, in a 1970 article Pepper added one further root metaphor. *Selectivism*, or selective system, functions as follows with respect to *means* and *ends*:

> if the drive for the means fails to yield satisfaction to the drive for the end, the former drive is eliminated ... the dynamic structure of the superordinate act spontaneously selects against incorrect subordinate acts and for the correct ones. (p.164)

Quite reasonably, Kilbourn and researchers after him equated world hypotheses with world view, though Pepper did not use this term himself. Kilbourn took Pepper's root metaphor theory as his world view, analytical device for evaluating the implicit projection of world view in secondary biology textbooks. Based on his observation that Pepper's root metaphor *mechanism* most closely matched the majority of explanations given in the textbooks examined, he concluded that most biology textbooks project a mechanistic world view. At first look it appears that Kilbourn's adoption of root metaphor theory solved the principal hindrance to world view research. Upon further consideration however, it becomes apparent that a concept of world view derived from Pepper's work does not appreciably reduce conceptual ambiguity after all.

The difficulty can be seen more clearly in the Proper, Wideen and Ivany study (1988), a study which purportedly analyzed the world views science teachers projected in their classrooms. They found that an individual teacher at times uses explanations corresponding to more than one of Pepper's root metaphors (p. 554). They concluded that an individual teacher at times projects different world views. The observation is not surprising, but it makes

little sense to claim that a teacher's world view, that is, the teacher's culturally-dependent, generally subconscious, fundamental organization of the mind changes from time to time during the class. The problem lies with Pepper's root metaphor theory. As a theory of world view it is simply too limited. Pepper's theory is about nature and causality; and though these are necessary parts of a world view, view of nature and causality are not sufficient to form a world view. In Chapter 4, an alternate interpretation of the Proper, Wideen and Ivany data will be offered.

The principal value of the Kilbourn and the Proper, Wideen and Ivany studies is that they are first steps in doing empirical world view research in science education.[4] As such they raised important epistemological questions. However, the further use of world view in education research requires a move beyond Pepper to a theory of world view that more articulately, more operationally defines this fundamental, cognitive macrostructure with all of its possible variations. For this one must look to the literature of cultural anthropology.

Anthropological World View Studies

World view is a term more familiar to cultural anthropologists than to educators, yet even for anthropologists the lack of an adequate theory of world view has been a problem:

> Although world view is one of the central subjects of American cultural anthropology, there is surprisingly little theoretical literature concerning it...(p.1). Although world view is a subject of immense importance in the social sciences and philosophy, a coherent theory of world view is nonexistent (p.9). This lack of a conceptual framework has been one of the main obstacles to the study of particular world views and their cross-cultural assessment. (Kearney, 1984, p.1)

Kearney's research is a response to this problem. He attempted to provide a theory that defines world view with the articulation necessary for guiding the cross-cultural study and assessment of world views. It may be argued that due to numerous American subcultures, there exists in American society significant world view variation. A further reasonable conjecture is that this

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[4]Teacher beliefs is a related avenue of research. Munby (1986) uses metaphor as an analytical device in his research, while Ledbetter (1987) employs the concept of theoretical orientation, for example.

variation influences the process of education, particularly science education. Therefore, Kearney's world view theory has important implications for educational research as well.

Kearney's book begins with a historical review of the concept of world view in American anthropology. The general paradigm used by American anthropologists doing world view research has been the *thematic paradigm* (or monothematic, configurationalist, or pattern paradigm). The thematic approach is an,

> attempt to discover and describe the underlying 'pattern,' 'configuration,' 'basic personality,' 'ethos,' or 'world view' of a society. What all of these concepts have in common is that they refer to an hypothesized mental principle that organizes in a distinctive way nonmaterial elements...of a given society. These mental constructs are assumed to shape social and cultural behavior and the material and nonmaterial results of this behavior. (Kearney, 1984, p.23)

The attempts made by cultural anthropologists to identify underlying cultural themes (or hypothesized mental principles), fall into two traditions. One is built directly upon the work of Franz Boas (1911) and the other on the later theoretical developments of Robert Redfield (1941,52). The Boasian tradition includes such anthropologists as Ruth Benedict (1934) and Margaret Mead (1928). As mentioned in Chapter 2, Benedict's *Patterns of Culture* typifies this tradition. She believed that by careful analysis one could find in a culture a single psychological theme that fundamentally ordered that culture's world view, a premise heavily influenced by Gestalt psychology.[5]

Redfield employed the Boas and Benedict total culture approach to world view research. In contrast, however, he considered the search for a single, overarching theme that would describe a culture to be an oversimplified approach. His innovation was to reconstruct the concept of world view as a composite of universally found categories (or universals). Specifically, these are a unitary *Self* and a tripartite *NonSelf*. The NonSelf represents Humanity (society), Nature, and God (or the transcendent). Redfield thus maintained the *Weltanschauung*, total culture concept while introducing an articulation that allowed the researcher to identify and study variation within a culture. The Redfield model allows one to say, for example, that the Western world view is *characteristically* mechanistic. The model further allows one to

[5]For a more recent article advocating a configurationalist approach to world view studies see Kieman (1980).

identify intra world view variations such as transcendent and secular variations of the characteristically mechanistic, Western world view.

Kearney recognized the importance of Redfield's theoretical advance, but still found it too limited:

> Redfield's concept of world view is mainly descriptive. Insofar as he speculated on the causes for differing world views he did so very generally...he did not attempt to explain why a certain type of society may have one world view, nor how world views change. Nor did he attempt to explain what connection there is between world view, environment, and behavior. (1984, pp.38&39)

Following Redfield, Kearney reconstructed world view as a composite of universals. His unique contribution to world view research is a model of world view with sufficient articulation to move world view research beyond the level of description to a level of analysis.

The Kearney Model of World View

The Kearney model begins with the idea that a world view is an organized set of fundamental, cognitive presuppositions about reality. He assumed that this organization is shaped by the,

> ...internal equilibrium dynamics among [world view assumptions]. This means that some of these assumptions and resultant ideas, beliefs, and actions predicated on them are logically and structurally more compatible than others, and that the entire world view will 'strive' toward maximum logical and structural consistency. The second and main force giving coherence and shape to a world view is the necessity of having to relate to the external environment. (p.52)

In other words, a world view tends to be internally consistent, in that presuppositions are logically integrated and universals are structurally integrated; hence, the model is termed *logico-structural.* A world view is externally valid in that the human need to relate to the external environment fosters coherence.

Kearney's ideas are similar to Redfield's. Both conceived of world view as a structural composite. However, based on an extensive review of ethnographic research, Kearney developed a composite of seven, basic cognitive categories or universals: Self, The Other, Relationship, Classification,

Causality, Space, and Time (see Figure #4, p.43). The Self and The Other are Redfield's categories. The salient difference between the models is that Kearney's model illuminates the articulation between Self and The Other. For example, it focuses one's attention on vital issues such as *relationship* of the Self to The Other, including the impact of The Other upon the Self. It raises questions of how The Other is *classified* by the Self. How does the Self understand *cause* to operate in The Other, etc.[6]

Kearney likens the seven universal categories to the diagnostic categories used by physicians:

> Although the doctor is confronted with a variety of patients, he can presumably describe the most significant medical facts about them in terms of...features common to all patients, e.g., blood pressure, pulse, respiration. (p.65)

While the physician's categories are filled by measurements, the world view categories are filled by presuppositions. Logically consistent presuppositions about reality are the content of world view universals. Each universal is composed of a hierarchically arranged set (or sets) of presuppositions, at the end of which is a final, absolute presupposition. This is a first order presupposition or an ultimate presupposition beyond which there are no others. One might think of a 1st order presupposition as akin to Aristotle's final cause. At the opposite end, these hierarchies blend into the cognitive frameworks with which educators are more familiar, e.g., commonsense and scientific theories. Collingwood provides an amusing story in which both ends of a hierarchy are apparent:

> ...if you were talking to a pathologist about a certain disease and asked him 'What is the cause of the event E which you say sometimes happens in this disease?' he will reply 'The cause of E is C'; and if he were in a communicative mood he might go on to say 'That was established by So-and-so, in a piece of research that is now regarded as classical.' You might go on to ask: 'I suppose before So-and-so found out what the cause of E was, he was quite sure it had a cause?' the answer would be 'Quite sure, of course.' If you say, 'Why?' he will probably answer 'Because everything that happens has a cause.' If you are importunate enough to ask 'But how do you know that everything that happens has a cause?' he will probably blow up in your face, because you

[6]Kearney's categories are thoroughly discussed in Chapter 4.

> have put your finger on one of his absolute presuppositions...But if he keeps his temper and gives you a civil and candid answer, it will be to the following effect. 'That is a thing we take for granted in my job. We don't question it.' (1940, pp.31&32)

At one end of the pathologist's mental framework is his knowledge of diseases and scientific research. At the other is a first order presupposition (Collingwood's absolute presupposition) in the world view universal, Causality. In this example the pathologist is drawing upon a typically Western, mechanical view of causality. Another person coming from a very different world view, or perhaps even from a Western subculture, might draw upon, for example, a more teleological or more fatalistic causal presupposition. In principle, not only cultures and subcultures of people, but also individuals can be identified by world view variations which result from the content variation in the seven world view universals.

Presuppositions Are More Than Beliefs

At this point one may wish to ask how world view and belief may be distinguished, if at all. Certainly, beliefs are implied in the terms, for example, Christian world view, Islamic world view, or secular world view. Ketner (1972) in his dissertation *An Essay on the Nature of World Views* argued that the basic concepts held within a world view are indeed fundamental beliefs. On the other hand, Kearney accepted the Needham (1972) position that *belief* itself is "a concept particular to the Western world" or Western world view (1984, p.51).

The arguments are rather esoteric and need not be considered at this time. Given that this text was written from within Western culture, Ketner's position that a world view is a *fundamental* system or network of beliefs is assumed. Belief and presupposition overlap considerably. However, the above emphasis on the adjective fundamental is crucial. Presupposition is the more specific term, and thus more appropriate for use in world view studies. Belief refers to a conviction of truth. The conviction can be by credit. For example, something is believed because of the authority of the source. The conviction can also be by credence which means that there exists a mental acceptance of truth. Belief by credence may come about because evidence has been shown. Neither of these types of belief implies certitude or trust in the belief, or that the belief is of any importance. However, as in religious belief, belief can imply all three, certitude, trust, and importance. The exact meaning of belief is determined by the context of usage. The difference between world view presupposition as belief, and ordinary belief is really one

of degree.[7] To begin with, there is always an earnestness and certitude about a world view presupposition that is not always present in ordinary belief. Collingwood's pathologist would no doubt consider his causality presupposition to be something much more certain than ordinary belief for which he would admit doubt.

Ordinary belief also implies consciousness, while presuppositions are frequently subconscious. Ordinary beliefs tend to have greater visibility than presuppositions. Many ordinary beliefs are easy to verbalize or describe, much more so than presuppositions. Ordinary beliefs are much more easily taught and learned. Furthermore, in the light of daily experience ordinary beliefs are malleable, while presuppositions tend to be self-confirmatory. Ordinary beliefs are many and specific, but operate only on appropriate occasions. World view presuppositions are superordinate beliefs. They are much fewer and tend to be in constant operation "though doubtless often with only a low charge" (Jones, 1972, p.83). Finally, while there are visible evidences of all ordinary beliefs, the indications of presuppositions are far more subtle and indirect.

Consider the case of two recent education articles containing the term belief, one in reference to world view and one in reference to ordinary belief. Bloom (in press) referred to belief as a part of a person's *context of meaning*, e.g., that the human species is qualitatively superior to all other animal species. Compare this usage with the use of belief in a study by Shaw & Cronin (1989). As examples of beliefs among preservice teachers they gave:

> Students are not automatically ready to work...
> Students are not well-trained listeners...
> Students sometimes try to bother teachers...(p.9)

Clearly Bloom's example of belief is by nature superordinate. The belief that the human species is qualitatively superior to all other animal species influences many aspects of life in many circumstances, but the belief that students are not automatically ready to work basically only influences life in the classroom. The first example concerns fundamental categories, and has breadth of scope and generality. The example from Shaw and Cronin is subordinate in nature due to its specificity. The modifier *framework of* preceding belief does give more of the presupposition sense. Nevertheless, to avoid semantic confusion, there is merit in reserving the term *belief* for its ordinary connotation.

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[7]This line of argument is based on Jones' notion of wide-range as opposed to narrow-range vectors (1972, p.83). Wide-range vectors according to Jones comprise one's *belief space* or world view.

CHAPTER 4

Logico-Structuralism

To summarize the arguments thus far, world view is the culturally-dependent, *implicit*, fundamental organization of the mind. This implicit organization is composed of presuppositions which predispose one to feel, think, and act in predictable patterns. Though at a fundamental level presuppositions are beliefs, the cardinal nature of presupposition requires one to always distinguish between belief at the presuppositional level and belief at lesser levels. According to logico-structuralism, presuppositions are the content of seven, universal categories: Self, The Other (NonSelf), Classification, Relationship, Causality, Space, and Time. The composite of these seven categories form one's world view. The balance of this chapter is given to a description of these categories. Wherever possible the description includes material from the literature of science education and related areas in an effort to demonstrate the appropriateness of world view research to science education.

Self and NonSelf: The 1st Order Universals[1]

Self: *Universe* (or cosmos) is the English language term for ultimate inclusiveness. Within the universe an individual's primary point of reference is himself or herself, i.e., the *Self*. The functioning of any human society is dependent upon self-identification and culturally determined notions of the nature of self (Hallowell, 1955). Every self (or a person's sense of self) exists and interacts within an environment, i.e., the *NonSelf*. Thus the ultimate inclusiveness is composed of the Self and all that is not the Self, i.e., the NonSelf. These two are the 1st order universals and together form the principal axis of a world view (Kearney, 1984, pp.68-70). This axis can be seen in Figure #4, Kearney's diagrammatic summary of logico-structuralism.

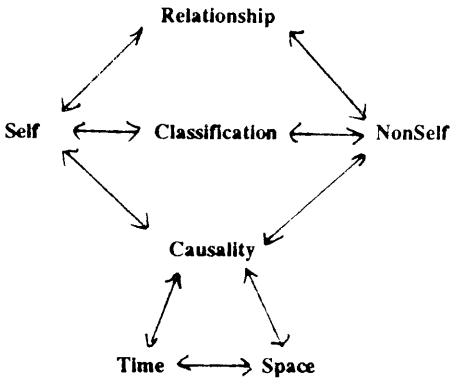

Fig. 4. Kearney's Logico-Structual World View Model

(Kearney, 1984, p.106)

The nature of Self varies between two polar extremes. At one pole are the individuals whose Self is continuous with the cosmos. These

[1]The seven universals neatly fit three groups here referred to as *1st, 2nd,* and *3rd order* universal categories, though Kearney does not observe these distinctions. Secondly, the term *The Other* in addition to being awkward fails to convey the full sense intended, "all that is *other* than the self." *NonSelf* has been substituted as a more self-evident, less awkward term.

individuals identify themselves with the NonSelf. The distinction between Self and NonSelf is minimal. In a sense, all is Self. At the other pole, nothing is Self. For these individuals the Self has become so depersonalized that they feel they have ceased to exist. In American society individuals at the first pole are mystics. At the second pole they are psychotics. Piaget has argued that from birth normal cognitive development is based on the gradual, progressive elaboration of a distinction between Self and NonSelf (Piaget, 1969).

Researchers have not shown much interest in the nature of self as a factor in science education. Locus of control research comes closest to addressing this world view issue.[2] In a 1982 essay on thought-life and life-style, Logan and O'Hearn discussed their view that the modern American sense of self is incompatible with science learning:

> The proficient science student should have (as a condition necessary, but not sufficient for science success) a self-concept as an acto-doer-observer; he ore she should approach experience and the world from a strong sense of self as I (I act, I do, I observe). Such a sense of self is a necessary component of empirical investigations, in which the self-as-observer stands (as "I") detached from the world and observes relationships among events. The individual whose sense of self is more one of "me" (receiver, consumer) will be virtually incapable of standing apart as "I" and observing how events relate to each other. He or she is too involved in observing the self as the object. (p.527)

This is a provocative statement that raises several questions about science learning and sense of self. As an opinion based on nonempirical cultural and philosophical studies, one has to wonder if this distinction between the action oriented "I" person and the passive, consumer oriented "me" person can be detected in the classroom. If so, is it a factor in science education as Logan and O'Hearn claim? Would not an action oriented, communal "we" person do just as well as Logan and O'Hearn's "I" person? Does the Logan and O'Hearn description of the modern self apply cross-culturally? Or, to what degree is the *detachment* Logan and O'Hearn speak of necessary for one to see relationships in events? Logan and O'Hearn's article has not been widely

[2]The section on Relationship, pages 49-52, speaks to research on locus of control and frames of reference.

quoted, yet from a world view perspective they have hit upon a rich research avenue.[3]

NonSelf: As stated above, the NonSelf is everything in the universe except the Self. The NonSelf can be divided into domains of equivalent, nonequivalent, or hierarchial taxonomic status. The simplest division is into domains of human environment and physical environment, or society and nature (see Figure #5). Most cultures, including Western culture, have preferred Redfield's tripartite division: Humanity (society), Nature, and God (the transcendent). Some of the most bitter controversies in American public education can be traced to differences in the Self-NonSelf axis and domains of the NonSelf. For example, a group of citizens may believe that the education establishment is promulgating a world view solely based on society and nature. In opposition stands a group of educators who may believe that the citizen group is unjustly trying to promote in the schools a religious world view.

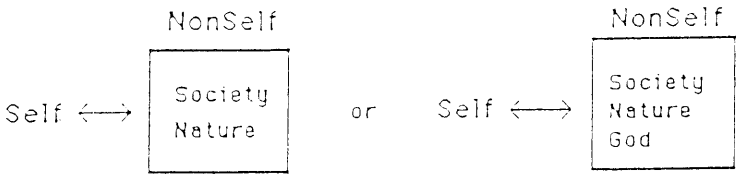

Fig. 5. Examples of Classifications in the NonSelf

As one would expect, the aspect of the NonSelf of interest in the science classroom is nature. From a world view perspective, one would ask: What is the image of nature projected in the science classroom? What is nature like according to science instruction? There is a rich literature on what people in different societies and at different times have believed about nature (see Glacken, 1967; Knopf, 1987). Is it wise for educators to assume that

[3]For further information concerning the concept of Self, see Gergen (1971) and Mauss (1985).

students coming into the science classroom will fully accept as both appropriate and important the image of nature projected there, when the literature indicates that there are many views of nature? Environmentalists have taken an interest in student beliefs about nature and perceptions of nature (e,g., Knopf, 1987). It is an interest that should be extended to all science educators.

Classification, Relationship, Causality: The 2nd Order Universals

Classification: The Self-NonSelf differentiation is the clearest, perhaps most significant example of a presupposition in the universal category *Classification*:

> Within a cognitively differentiated universe the most fundamental classification categories are Self and the [NonSelf]; this is the reason they are treated as universal. (Kearney, 1984, p.80).

Beyond the Self-NonSelf classification there are classifications within the NonSelf domain. Figure #5 shows two classification possibilities for the NonSelf, but there are many. A third possibility is the pantheistic fusion of God and Nature as found in classical Greek thought, some Eastern religions, and in some areas of New Age thought. Furthermore, there are subclassifications within classifications. Different partitionings of the world can result in frustrating encounters, especially when the world view variations involve teacher and student. Consider this student/teacher exchange that follows when a teacher asks the class to name the two groups into which all living things can be divided:

Lucy:	People?
Teacher:	People are just part of one of the two divisions.
Peter:	Plants and animals.
Teacher:	Good for you, Peter. That's right. Everything in this world is either plant or animal. People, Lucy, are animals, so they fit in this division.
Lucy:	People aren't animals, they're humans.
Teacher:	People are animals, the same as cats and dogs and so on. [Much laughter and several loud objections by a large number of pupils speaking simultaneously.

It appears that they disagree with this last statement.] People *are animals*. What's wrong with that? They're not plants are they?

Jimmy: But people talk, and have two legs and arms, and move and can think. Animals aren't like that. [laughter] (Russell & Munby, 1989, p.108)

Similar exchanges have been reported by other researchers investigating students' untutored ideas about life (e.g., Looft, 1974; Brumby, 1981, 82). Concepts such as higher and lower animals, or the belief that human life is qualitatively different and superior to other animal life are indicative of Classification presuppositions concerning life forms in nature. World view theory suggests that students' ideas, such as that expressed in the above dialogue, are better understood in the light of their world view presuppositions. New investigations from a logico-structural perspective would ask what categories these students are applying to nature and how these relate to the categories used in instruction.

	NonSelf-domains	Real	Unreal
Theist	Supernatural	God	Ghosts
	Nature	People	Dreams

	NonSelf-domains	Real	Unreal
Atheist	Nature	People	God

Fig. 6. The Attributes: Real and Unreal

Yet another classification of the NonSelf is between the real and unreal. Figure #6 represents the NonSelf domains for a theist and atheist. In this example *real* and *unreal* are attributes of the various domains into which the NonSelf is classified, but not domains themselves. For the theist some of the content of the supernatural domain is real, but for the atheist, the entire domain is unreal. Kearney rightly pointed out that one must know the attributes of a NonSelf-domain as well as the content:

> it is possible that two people may conceptually group ...ghosts, spirits, the Devil. Knowing this grouping alone tells us little about their respective world views. However, if we know that for one person these items are grouped together as elements of folk tales and superstitions, while for another sources of sickness and sin, we gain insight into the associated dimensions of Causality and Relationship in their respective world views (1984, p.82).

Kearney's example from anthropology can easily be replaced with one drawn from a science classroom. The following dialogue is from Wightman's investigations of students' understanding of particle theory:

> P: I can't really explain, but there's summat where you think, well this table it's made up of particles - I think it's too, well you can't see any particles or owt, so its just - just can't believe it. You know, that this table's made out of particles - hundreds of millions.
>
> T: You don't believe it?
>
> P: Well, I do in me own way, you know, but well wood's wood, I mean it grows from trees - you know more or less - well - sometimes - if a teacher tells you that its made out of particles you think - well fair enough its made out of particles, but its, you can't really believe that this table's made out of particles.
>
> T: What about the atmosphere in this room? Can you accept that that is made of particles?
>
> P: Not really... (1989, p.69)

There may well be times when a science teacher and a student agree on the conceptual grouping of nuclei, atoms, and molecules, as do the teacher and student above. The attribute however, for the teacher is submicroscopic reality, while for the student it may be simple unreality. For one it may be significance, while for the other it is insignificance. The science teacher and the student are each using classification categories that reflect his or her attitudes and presuppositions about the nature of reality.[4]

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[4]See page 54 for an example from science education where Classification and Causality presuppositions are working in conjunction.

Relationship: It is difficult if not impossible for anyone to discuss Self and NonSelf totally independent of each other. To speak of the Self invariably involves some context, i.e., the NonSelf. To speak of nature is to invariably invoke the terms of Man's relationship with nature. It is in the interactions of Self and NonSelf that the senses of Self and NonSelf form. They are structurally integrated; thus, the 2nd order universal of logico-structuralism, *Relationship*, i.e., the relationship between the Self and NonSelf:

> The Relationship universal arises from the necessary condition that survival of Self depends on its interaction with the [NonSelf], the latter being both the social and physical environments in which the Self is located. The Relationship universal is important because the way in which people view interaction with other people and things in their habitats significantly affects the way in which they behave. (Brown 1984, pp.99&100)

For example, a child raised in a warm, secure home can be expected to develop a confident sense of self. The child comes to know the world (i.e., the NonSelf) to be orderly and nonthreatening. An abused child more likely grows up with low self-esteem. A child raised in an environment of unexpected trauma may come to see himself as a powerless being living in an unpredictable world.

The concept of *psychological differentiation* as developed by Witkin et al. (1962) suggests that society and culture strongly influence one's relationship with the environment:

> Differentiation refers to an individual's segregation of psychological activities, one instance of which is the way boundaries are set up between an individual and the outside world. As these boundaries develop, the individual begins to formulate internal frames of reference, relying less and less on external sources as guides to behavior. (Hvitfeldt, 1986, p.66)

As a person becomes more reliant on internal frames of reference, that person becomes more *field-independent* and less *field-dependent*. However, among different socio-cultural groups, what is considered a normal position on an independent-dependent spectrum varies considerably (e.g., Hvitfeldt, 1986). Locus of control and locus of responsibility are avenues of inquiry related to field of reference concepts. Though not as often studied in cross-cultural con-

texts, one sees in locus of control and locus of responsibility research the same implicit recognition of the importance of Relationship presuppositions.[5]

Of a more philosophical bent is the presumed status of Self vis-a-vis the NonSelf. Fundamentally the status relationship between the Self and NonSelf can be one of harmony, subordinance, or dominance. In actuality there is likely to be mixing. For example, the Self-NonSelf relationship with regard to the individual and society may be one of harmony, while the individual-nature relationship one of dominance (Kearney, 1984, pp.72-78). Historically, a relationship of dominance derived from the *Genesis* account of creation was crucial to the development of experimental science (Hooykaas, 1972; Glover, 1984). In the words of one Japanese observer:

> in the Western idea, man was not an ordinary part of nature. He was a specially privileged creature, and nature was subordinate to him...he was the master of the natural world, which was at his disposal to analyze, examine, and make use of...since the natural world and the whole universe were manifestations of God's creation, the study of it was not only a useful but also a highly esteemed endeavor...such an outlook provided some of the important religious motivation which fostered the development of modern science in the Western world. (Watanabe, 1974, p.280)

This dominance theme continues to be important in science today, though not without problems (see White, 1967; Young, 1974). In stark contrast, for traditional Chinese and Japanese the relationship between Self and nature is one of affinity and sympathy. The difference between East and West is nicely illustrated by a story told to Watanabe by an American missionary to China:

> Three men went to see Niagara Falls. One was an Indian from India, one was a Chinese, and one an American. On seeing the falls, the Indian, as a matter of course, thought of his god, manifested in this grandeur of nature. The Chinese simply wished to have a little hut beside the falls, where he might invite a friend or two, serve tea, and enjoy conversation. The American, however, on viewing the falls, immediately asked himself what could be done to make the most of such an enormous amount of energy. (p.279)

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[5]For example research see Rotter (1966); Brooks & Hounshell (1975); Helms & Giorgis (1980); Scharmann (1988).

Although this story is about stereotypes, there is the essence of truth. Americans frequently view nature as an object for "mastery" (White, 1967; Young, 1974). In other cultures nature is more likely to be valued for its beauty, if not actually held in reverence. These differences in world view have consequences. Watanabe noted that despite the frequency of earthquakes in Japan, it was only after contact with Westerners that the Japanese began the scientific study of earthquakes. According to Watanabe, "this can be explained largely by [the Japanese] attitude of coexisting with nature" (p.281). American feminist literature records a similar attitude. The feminine presuppositions undergirding the Self-NonSelf relationship are characterized by:

> interrelatedness and interconnectedness, wholeness and oneness, inseparability of observer and observed, transcendence of the either-or dichotomy, dynamic and organic processes ... (Perreault, 1979, p.4)

Feminist scholarship such as Keller's seminal biography of Barbara McClintock, *A Feeling for the Organism* (1983), however, has helped to strengthen the feminist contention that good science does not necessarily require the traditional, Western view of nature.[6] It is interesting to note that some observers believe that the Eastern Self-NonSelf relationship will result in unique contributions to science, especially in ecology and anthropology.[7]

The traditional Western dominance theme does not necessarily lead to reckless individualism nor to the wanton exploitation of nature (Young, 1974). There are however those who believe that it does so necessitate, and they are not always gentle in their expressions and acts of opposition. Of the West the Indian philosopher Radhakrishnan commented:

> the modern mechanistic societies lack the vision of self in man. They recognize only an external mechanistic universe reflected in the machines that man has devised. This is how disintegration becomes the key image of the modern world. (1967, p.145)

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[6]Also see Gilligan (1982). For a further discussion of a feminist position vis-a-vis a scientific world view, see Chapter 5, p.70.

[7] See for example, Frisch (1963); Watanabe (1974); Harding (1989). For an interesting discussions of how science education might look incorporating alternatives to a mechanistic view of nature see Franklin (1980); Miller (1980); and Scheirer (1980).

In the United States a small but growing group of people have adopted a radicalized eastern view of the relationship between Self and NonSelf. As a result organizations such as the Animal Liberation Front and Earth First! actively seek the end not only of all animal experimentation in science, but as well an end to meat, leather, and wool industries (Los Angeles Times 1989, p.A6). The radical activists demonstrate how serious world view differences can be.

Causality: Kearney developed his concept of Causality from a Piagetian perspective (1984, pp.84-89). Here science educators find more familiar ground because of the shared interest in Piagetian theory and cause and effect. Kearney employed Durkheim's definition of causality:

> The first thing which is implied in the notion of the causal relationship is the idea of efficacy, of productive power, of active force. By cause we ordinarily mean something capable of producing a certain change. The cause is the force before it has shown the power which is in it; the effect is this same power, only actualized. (Durkheim, 1965, p.406)

Kearney argued that an individual constructs his or her world view based on the dialectical forces in one's life, that is between Self and NonSelf, especially during formative childhood years. Therefore he incorporated in his theory Piagetian stages of development where the nature of cause and effect changes for a child with growth and experience. Following Piaget (1969), presuppositions of the Causality universal develop through periods of participation, animism, artificialism, finalism, and force:

> ...in feelings of 'participation,' there is an assumed affinity of Self with external objects...closely allied with this is the notion of 'animism,' which endows things with consciousness and life. In the third form, 'artificialism,' there is the uncritical assumption that objects obey will and intention, and in doing so are organized and act for the good of men...that things exist for and are organized for man is the 'finalistic' assumption. To the extent that this notion exists, the world is seen as teleological. The fifth type of adherence is the notion of 'force' or 'power,' which is attributed to things such that they make efforts as do muscles. (Kearney, 1984, p.87)

Kearney argued that Piagetian mental development involves the gradual development of a mechanical view (or scientific view, see Kearney, p.70) of causality in conjunction with the gradual elimination of the above five

adherences, although some often continue into adulthood. The extent of adherences in adulthood is a function of an individual's ability to completely distinguish between Self and NonSelf, i.e., "dividing off the internal world from the external" (Piaget, 1969, p.246).

Kearney accepted Piaget's dialectical view of mental development and use of mental stages. He employed Piaget's adherences as aspects of the Causality universal useful for describing and comparing world views. However, he rejected Piaget's conclusions as being culturally determined.[8] Piaget's French Swiss children developed mechanical viewpoints precisely because they were French Swiss, and not for example, Nuer or Hausa. Taking mechanical causality as the hallmark of advanced mental development would doom the majority of the world to mental underdevelopment. Robin Horton's *African Traditional Thought and Western Science* (1967), is an illuminating account of traditional African thought. Horton argued that traditional African thought is indeed complex and formal, but based on a rationality of its own. However, in contrast to Western thought, it is nonmechanical.[9]

Of course, among Westerners there are also those whose thinking is dominated by nonmechanical concepts. Teleological thinking is an issue that has frequently been addressed in the science education research literature, and provides a good example of Causality variations in a typical Western world view. Especially with regard to the life sciences, researchers have frequently noted that some students prefer explanations that have to do with the purpose of a structure or action.[10] At one level such explanations simply mean that a consequence can be used to explain an action. The function provides an explanation for the structure. For example, the pumping of blood is an explanation for the heart. Teleology at this level does not pose a serious problem in the classroom, if any problem at all. The teleological causality unaccustomed to science, however, is the causality of transcendent purpose. There is a reason for existence or function that transcends material, mechanical terms.[11] The point is, such a preference does not necessarily indicate cognitive immaturity. It can just as well indicate that in the students' view of the

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[8]For enlightening accounts of cross-cultural Piagetian research, see Buck-Morss (1975); Cole & Scribner (1974); Dasen (1974).

[9]Also see Elkana (1977) and Urevbu (1988).

[10]There is an excellent set of articles by Jungwirth on teleology and anthropomorphism (1975a,b,c; 1977; 1979). Also see Wandersee & Mintzes (1987) for a bibliography of research on conceptual development with regard to the life sciences.

[11]See the example in Chapter 6, p.91.

world, purpose is of primary importance. In such instances there is a significant mismatch between the presupposition of the student and the presupposition of classroom instruction.

For two decades science education research on student learning has been dominated by Piaget's concepts of concrete and formal thought, and the development of cognitive processes from concrete to formal. In recent years the investigation of commonsense theories and misconceptions has brought about a change of focus from the concept of concrete/formal thinking to the concept of adherences. The next step is to investigate the epistemological frameworks which make the adherences more intelligible and certainly less pejorative.

Reinterpreting a Root Metaphor Study: To further illuminate the concept of causality as an aspect of world view, it is instructive at this point to return to Pepper's root metaphor theory and its use in the Proper, Wideen and Ivany study (1988). These researchers found that their biology teachers used explanations representing four root metaphor categories: formism, mechanism, contextualism, and organicism. For example, when the subject was classification the teachers tended to use formal explanations, but mechanical explanations with genetics and cell biology (p.554). Such observations are predictable using the logico-structural model of world view where there is an articulation between Self, Causality and NonSelf. As one would expect, the world (NonSelf) for these teachers is composed of many categories. At some appropriate level a categorical distinction in the teachers' epistemological framework is made between multicellular organisms and individual cells, including important cellular molecules. The biology teachers' multicellular category is likely to be further divided according to similarities and differences among organisms, in other words, according to a standard phylogenetic taxonomy. In this case the articulation between Causality and NonSelf is that structural features determine classification, thus the formism detected in the classroom when the subject is something like phylogeny. Similarly, at the cellular level the biologist uses many more concepts from physical science where mechanical explanations predominate. In this case the articulation between Causality and NonSelf is that phenomenon at the cellular level have mechanical causes, thus the mechanism detected in the classroom when the subject is something like genetics. The teachers in study do not have variable world views. What they have is a variable concept of causality that is rationally related to the their understanding of the world. The root metaphor theory does not allow one to readily see this distinction.

Similarly, Kilbourn's 1984 study of textbooks actually speaks only to one aspect of world view. The sense of causality projected in the biology textbooks he studied was mechanistic. But what view of nature did the

textbooks project? What did the textbooks assume about the relationship between people and nature? Though it does not diminish the value of Kilbourn's research, these and other questions would have to be answered before this research could accurately be considered a complete world view analysis.

There are other examples of science education research on teacher behavior that can profitably be informed by the logico-structural view of causality. Dagher & Cossman (1990) reported on a qualitative study of explanations used by junior high science teachers. In their analysis they classified observed teacher explanations into ten categories, not all of which were considered desirable for the science classroom. In their concluding remarks, the researchers noted that in future studies interviewing the teachers would provide important contextual information concerning the use of explanation types. The Dagher & Cossman study is quite similar to the Proper et al. (1988) study. Both investigations involved categorizing teacher explanations. Unlike the 1988 study, Dagher & Cossman did not use an **a priori** classification system, nor did they consider their study to be world view related. It is, however, as much a world view study as Proper et al. (1988). The teachers in the classroom use explanations that fit their partitioning of the world, their understanding of the relationship between Self and the world, and the different ways to view causality in the world. Goodson & Walker (1989) contend that, "biographical material on teachers should be an integral part of accounts of classroom life" (p.111). Quoting a folklorist, they point out that teacher behavior and teacher are analogous to song and singer:

> I began to realise that, for me, the people who sang the songs were more important than the songs themselves. The song is only a small part of the singer's life and the life was usually very fascinating. There was no way I felt I could understand the songs without knowing something about the life of the singer, which does not seem to apply in the cases of most folklorists. They are quite happy to find material which fits into a preconceived cannon and leave it at that. I had to know what people thought about the songs, what part they played in their lives and in the lives of the community. (Pegg, 1989, p.111)

Thus, the teacher interviews that Dagher & Cossman suggest should be used to put *life* into their research, that is, the lives of the teachers involved. For the researchers to understand the teachers' behaviors, let alone to promote change, the researchers must see teacher behavior in terms of the several world view categories (e.g., Self, Relationship, NonSelf), not simply Causality

in isolation. Researchers need to see teacher behavior in the context of teacher life.[8]

To conclude this section on Causality it should be noted that some question the continued use of cause-and-effect, mechanistic concepts in science and science education. Indeed, the contention that cause-and-effect causality has disappeared from modern physics has gained a degree of popularity. This is a philosophically erroneous deduction from modern quantum mechanics. As Fermilab cosmologist John L. Dykla has recently written:

> All modern science is predicated on the philosophical assumption that its subject is comprehensible...Of course, the advent of quantum mechanics in the twentieth century has compelled reappraisal of the deterministic paradigm of earlier science. Still, the activities of physicists are grounded in a belief in the existence of objective laws that correlate our observations of natural phenomena and allow at least some limited measure of successful prediction. (1989, p.169)

Even if one granted in physics a complete change in the understanding of causality, the rest of science still lives in a rather Newtonian universe. Furthermore, it is difficult to conceive of a science education program not based on a fairly traditional notion of causality (AAAS, 1989). The banishment of Newtonian cause-and-effect causality would itself indicate a significant world view shift in the Western world.

Space and Time: The 3rd Order Universals

Space: There are many examples of how people view space differently. Ideas about space are a common difference between urban and rural dwellers. Unlike his rural cousin, a person who lives in the city often has little practical awareness of the compass directions east, west, south, and north. For the city dweller, direction is generally a matter of uptown, downtown, left and right. On the other hand, a walk of a *short distance* for the rural dweller is likely to translate to a much longer distance for the urban dweller who is accustomed to more compact space (Musgrove, 1982). In the science classroom, spatial distances often are very large or exceedingly small. In either case it is not the space common to the every day experiences of most children.

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[8]The same argument can be used regarding the study of teachers' use of analogies in the process of explanation. See for example, Treagust et al. (1990) and Duit (1990). For similar research but with metaphors, see Pope & Gilbert (1983) and Muscari (1988).

Consider Dart's investigations in Nepal concerning another aspect of spatialization (1967; 1972). As a part of his studies of readiness for modern science learning among traditional Nepalese children, Dart had Nepalese and American children draw from memory maps showing the way from home to school. From the maps he anticipated learning more about how the children dealt with abstractions. Referring to the maps reproduced in Figure #7, Dart noted that the,

> fifteen-year-old Nepalese boy is apparently describing the "process of going" rather than spatial relationships ... in fact, the house and school are on different paths. An eleven-year-old US boy includes spatial and directional clues, as well as symbols, in his map. (1972, p.52)

He concluded that the Nepalese children drew their maps based on "*sequential* rather than spatial constructs" (p.54), and that this was quite reasonable given the environment in which they lived. Dart's concern for these children wasthat they were accustomed to a type of abstraction that was foreign to science instruction. In a different setting, David Hawkins noted that people tend to,

> have a perceptual-commonsense way of taking things as 'big' and 'little' without reliance on the analytically defined concepts of length, area, and volume. From the commonsense-perceptual point of view this is entirely reasonable. (1978, p.7)[13]

Unfortunately, this commonsense-perceptual view does not well serve the student or teacher in a science classroom, whether the classroom is in Nepal or the USA. Hawkins referred to this type of problem as a *critical barrier phenomenon* to science which cannot be breached by instructional ingenuity alone. It requires greater understanding of the personal contexts that students bring to the classroom.

Another intriguing area of science education research, that may well involve world view presuppositions in the Space universal, is the research on visual/spatial thinking. According to McCormack (1988) visual/spatial thinking:

[13]Also see Apelman (1982).

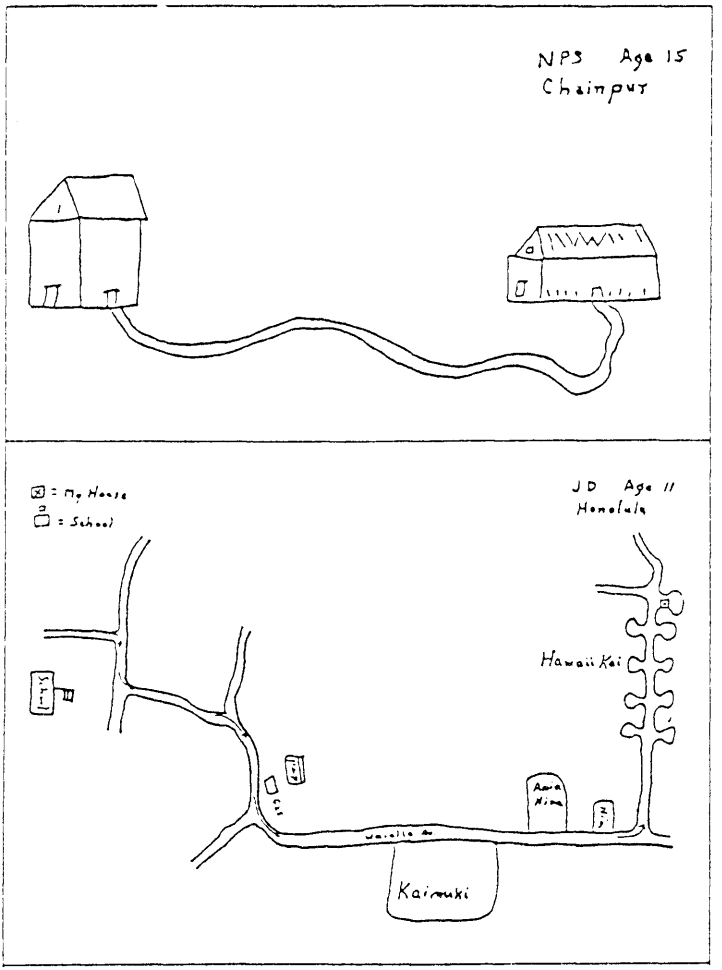

Fig. 7. Maps Drawn by Nepalese and American Students

(reprinted from Dart, 1972, p.52)

> involves purposeful use of your 'mind's eye' to develop mental pictures or images. At higher levels, it is characterized by both logical and creative processing of mental images to solve problems, create new ideas, improve physical skills, or even quite tumultuous emotional states. (p.2)

Some research indicates that male students generally score higher than female students on measures of visual/spatial thinking. The researchers attribute this to the type of environment in which boys grow up (McCormack, 1988). The gender factor in visual/spatial thinking is, however, a hotly debated topic (see for example Howe & Doody, 1989). If there is a gender factor, some might speculate that a feminine oriented world view has an underdeveloped Space universal. However, logico-structuralism suggests other possibilities. Visual/spatial tests appear to involve linear, Euclidean relationships and shapes. It would be interesting to test the gender hypothesis using a nonlinear, non Euclidean visual/spatial test. The results of such an investigation might indicate that the gender factor reported in some research is an artifact of the researchers' world view, rather than an accurate assessment of visual/spatial thinking.[14] Consider the example of Japanese scientists studying the behavior of wild monkeys:

> To most observers, all monkeys look very much alike, and it is difficult to identify individuals in a group. Therefore, most Western fieldworkers catch the animals and mark them with numbers. The Japanese, however, became acquainted with the faces, general appearance, and personalities of the monkeys, and succeeded in identifying individuals not by numbers but by giving them names of popular and traditional figures from Japanese history. (Watanabe, 1974, p.281)

Something quite similar could no doubt be said of Jane Goodall and her work with chimpanzees, or Dian Fossey and her work with gorillas. The ability to distinguish individual monkey, chimp, or gorilla faces involves mental imaging, but imaging quite different from what is required to visual lines and angles. One could thus hypothesize that women's visual/spatial thinking should be

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[14]There are a two studies of particular interest in the literature concerning world views in collision. One is Derek Freeman's (1983) analysis of Margaret Mead's famous work in Samoa (1928). Freeman contends that Mead's findings were in error and that she found exactly what she wanted to find based on her own world view. The second example is Marvin Olasky's study of the journalistic coverage of the Scopes trail (1986). Olasky contends that the reporters who went to Dayton had a world view quite different than the residents of Dayton. As a result, "they incorrectly portrayed the evolution-creation debate as a battle between intelligence and stupidity and, as a result, the stereotypes they created persist today."

conceptualized differently from what is now typically done in visual/spatial research.[15] Spacial studies testing the recall of complete photographs or pictures, or recall of colors and color relationships would be interesting.

Time: Time is a more complicated structure. Within a world view Time can have one of three basic orientations, past, present, or future, each of which is a different first-order presupposition. Historically there has been a strong future orientation among Anglo Americans, traceable in part to Puritan and Calvinistic influences in colonial America. Success in American education generally requires such an orientation. Kearney noted that a future orientation is "compatible with scholastic achievement in that such a student is more able to resist immediate distractions and focus energies toward...good grades, degrees, etc." (1984, p.95).

Kluckhohn and Strodbeck (1961) noted that Hispanic people are more present-oriented, in contrast to the future-orientation of many Anglos. The here and now is more real than anything that may happen tomorrow. A world view Time universal can also be past-oriented. Kluckhohn and Strodbeck cited the Chinese and Mormons as examples. Time oriented to the past is manifested in ancestor worship by the Chinese and the Mormon interest in genealogies "by which they attempt to discover spiritual links with unknown ancestors" (Kearney, 1984, p.97).

In addition to orientations of time, there are different images of time. Some people have an oscillating image of time where time either runs in circles or zig-zags. According to Kearney:

> The essential feature of this image of time is that time is seen as rhythmically swinging back and forth between recurrent markers. Such an image occurs most strongly in technologically simple preliterate societies. (1984, p.99)

Alternatively, the image of time can be linear, like a timeline that a history teacher might use. Time moves from the past into the present and on into the future, one-way and irreversible. Since time past cannot be recovered, and the present also will soon be gone, it behooves one to look to time yet to come. In other words, "a linear image of time is structurally compatible with a future orientation" (Kearney, 1984, p.101). The co-occurrence of these first order presuppositions is common in the West, and can be traced back through the Judeo-Christian tradition to the early Hebrews. In *Genesis* there is a specific

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[15]This hypothesis could be based on women's quite different relationship with nature, as reported by some researchers, e.g., Halpin (1989).

creation event at which time starts. It proceeds through Jewish history looking toward the coming of Messiah. The Christian tradition adopted the Jewish sense of history, except that for Christians time points toward the second coming of Messiah and the culmination of all time (Glover, 1984). These first order presuppositions in the Time universal formed an important distinction between the Medieval world view and the world view of Classical Greece and Rome. They were crucial for the development of modern science in Europe (see Foster, 1934; Klaaren, 1977).

In the research literature student concept of time is not an issue that has received much attention. Without a world view model such as logico-structuralism there has been little to draw attention to the possible influence of time concepts on science learning. The readily visible cultural differences between Thailand and Japan did lead Mori, Kitagawa & Tang (1974) to address the issue of time orientation in a school setting. Time is nonlinear in Buddhist oriented, Thai culture. In Japanese Christian and secular cultures, a linear concept of time predominates. The researchers observed Thai and Japanese children who were attending school where scientific concepts of time were taught. The researchers found schooling to influence the time concepts of many of the children in the study, but not all. Further investigations of this type, only informed by world view concepts, would be both interesting and profitable. For example, one could ask whether there are differences in other world view categories that would help explain why some children's sense of time was influenced by schooling while others not.[16]

Attributes of Time: In addition to the orientation and image presuppositions in the Time universal, there are important attributes (Kearney, 1984, pp.102-106). Time can vary in depth or range. For example, the future can be a few months, a few years, a few decades, or far more. One likely consequence is that short-range planning is preferred by those who have *shorter* futures. Another attribute is pace. For some people time walks; for others, it runs. If it runs, there is a greater need for the precise measurement of time. Furthermore, faster time generally occurs in a world view along with linear and future-oriented time.

It has been mentioned that a future orientation serves a student well. In the science classroom, time has further importance. The methods of science are such that time has a very specific meaning and is used with great precision. One can easily see how a student's non-scientifically compatible notion of time would be challenged in a science classroom. For some

[16]See Logan and O'Hearn (1982) for a nonempirical discussion of the effect of sense of time on science learning.

students, that challenge may result in confusion or even render meaningless many aspects of science.

At this point one might suggest that the universals Space and Time are actually no more than attributes or characteristics of the NonSelf. Certainly, Space and Time are always thought of in conjunction with some aspect of the NonSelf. However, unlike the attribute *real/unreal*, some fundamental form of space/time cognition is common to all people (Kearney 1984, pp.89-92). Note that in Figure 4 (p.43), Causality is bracketed by the universal Relationship on one side, and Time and Space on the other. One's understanding of Causality is dependent upon both the relationship between the Self and NonSelf, and upon our understanding of Space and Time. These four universals are intimately related in that only with some concept of space and time, in conjunction with some concept of how one relates to the external world, does a sense of Causality become conceivable (1984, pp.89-107).

To conclude this section recall that the primary difficulty with the Boasian and Redfield world view traditions was oversimplification. Their approaches did not facilitate analytical research, and were primarily used for description. Even at that, the configurationalist approach to world view glosses over many differences. There is some truth in the statement that the Western world view is mechanistic (Pepper, 1942), but there are many degrees of mechanism and many interactions with other factors. Kearney's theoretical model with its seven interacting universals, provides the analytical tool for studying subtle, intra world view variations, without sacrificing the ability to draw broad generalizations about world view in a society. Similarities in the Causality universal may lead one to agree with Pepper that the West has a mechanistic orientation. However, the logico-structural model with its six other universals keeps one from glossing over substantial intra-world view, subculture variation.

CHAPTER 5

Science, Science Education and World View

Darwin's twilight lament: I have said that in one respect my mind has changed during the last twenty or thirty years. Up to the age of thirty, or beyond it, poetry of many kinds...gave me great pleasure, and even as a schoolboy I took intense delight in Shakespeare...I have also said that formerly pictures gave me considerable, and music very great, delight. But now for many years I cannot endure to read a line of poetry: I have tried to read Shakespeare, and found it so intolerably dull that it nauseated me. I have also almost lost my taste for pictures or music... I retain some taste for fine scenery, but it does not cause me the exquisite delight which it formerly did... My mind seems to have become a kind of machine for grinding general laws out of large collections of facts ... (quoted in Owens, 1983, p.38)

CHAPTER 5

The possibility and definition of a *scientific world view* must be addressed before going on to consider how world view, and logico-structuralism in particular, can effectively be used in science education research. The preceding pages alluded to the fact that a world view is not usually associated with an individual. Rather, one might think of an ethnic group and, for example, speak of the Navajo world view (Witherspoon, 1974). Or one associates world view with civilizations, religions, and eras (see Quigley, 1979). Again, as previously mentioned, one might speak of a Western world view, an Eastern world view, or a Medieval world view. Of immediate interest is that educators speak of a *scientific world view*.

The Growth of Science

What is called the modern scientific world view is a uniquely Western phenomenon born out of the intellectual tumult of the 16th, 17th, and 18th Centuries in Europe. With the rise of Newtonianism, a mechanistic ideology triumphed among the European literati over its competitors, the Aristotelian "world as an organism" view, and the Neo-Platonic "mysterious universe" view (H. Kearney, 1971). The triumphant mechanistic view exemplified by the philosophical arguments of Rene Descartes and the experimental work of Newton and Boyle became the basis of modern science. This mechanistic view is essentially reductionistic, the explanation of the whole to be found in the parts. In this view machine-type analogies are considered appropriate for explaining natural phenomena. For example, in B.F. Skinner's studies of human behavior he quite bluntly wrote, "Man is a machine" (1971, p.202). And though modern physics is modifying the mechanistic, scientific view, it remains a thoroughly empirical view that stresses the importance of testable hypotheses concerning natural causes within a lawful universe.

These remarks are about intellectual history but bear an obvious relationship with the history of science, a discipline that can hardly be broached without some comment on Kuhn's seminal work *The Structure of Scientific Revolutions* (1970). With regard to the present topic, it is indeed true that Kuhn used the term world view in reference to the scientific paradigms he was discussing (p.111). It has already been pointed out that people frequently use the term world view where the world that they have in mind is something considerably less than a totality. The worlds that Kuhn had in mind are the disciplines of science. Thus, for example, in the *world of the biological sciences*, Theodosius Dobznasky can say, "nothing makes sense in biology except in the light of evolution" (1973, p.125), implying that evolutionism is the world view or paradigm of biology. If biology is a world, it is a world within other worlds; and so the evolutionism that is being called the world view of biology is in fact only one aspect of a much larger world

view - the world view of the culture in which a biologist lives. Kuhnian paradigms are themselves grounded in world view.

The world view of Europeans founded on Greco-Roman and Judeo-Christian traditions, provided the context in which the new scientific thinking developed (Glover, 1984). In turn, the new scientific thinking strongly influenced the European, later to be the Western, world view.[1,2] For example, by the mid 18th Century, the European sense of what it meant to be *civilized* had to do with proper social behavior, that is, etiquette and manners. Europeans found their distinctiveness in religion, political concepts, and physical appearance. However, in the 19th century, a civilized society was one that had attained a certain level scientific and technological achievement; and,

> the European's scientific outlook and capacity for invention were more and more frequently cited as the basic attributes that set them off form all other peoples. (Adas, 1989, p.194)

Over the decades, the influence of scientific thinking substantially closed the gap separating the world view of the people and the ideology of the literati to such an extent that some in the 20th Century apply the label of mechanism to the Western world view *in toto* (e.g., Pepper, 1942; Radhakrishnan, 1967).[3]

In modern, Western education the development of a scientific world view is frequently given as a primary goal of science education. However, if world view refers to epistemological macrostructure, problems begin to surface. Do educators really wish to advocate that all of experience should be seen through the eyes of science? Probably not, recognizing that there are valid non-science related aspects of life and experience. If everyone were to accept a reductionistic, physio-chemical view of Man, one might well come to agree

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[1]An understanding of people and culture requires that one distinguish the ideology of an elite few from the cultural idiom of the day, i.e., the world view of the people. See Sewell (1985) and Skocpol (1985).

[2]For example, see Adas (1989), *The Machine as the Measure of Man*. This is a highly informative account of how European science and technology influenced European estimation of the essential uniqueness of European culture, and how this estimation was used to assess the value of non-western cultures.

[3]Mechanism is a pejorative term in many quarters of academic work. This is largely because mechanism has become synonymous with mechanistic world view. The term becomes less troublesome when it is understood that the profitable use of mechanistic concepts in research does not necessitate a world view dominated by such concepts. For an excellent historical account of mechanism see Dijksterhuis (1986).

with Radhakrishnan, "the modern mechanistic societies lack the vision of self in man...disintegration becomes the key image of the modern world" (1967, p.145). It would be more appropriate to argue that education should foster presuppositions that allow for the possibility of science understanding and positive attitudes toward science, i.e., a scientifically compatible world view. The development of a scientifically compatible world view among Western students is somewhat analogous to the geographical spread of modern, Western science.

Since its birth the phenomenon of modern, Western science and its attendant mechanistic view of nature have slowly spread beyond European borders. In 1967, George Basalla presented a three-stage model that describes this expansion and growth of science in nonscientific societies. In a new area, science is at first dependent upon older science and scientists. For example, American science was for many years dependent upon European science. Basalla suggested that for the new science to become independent, seven tasks needed to be completed. The first task and the one most pertinent to the subject of world view is that a,

> resistance to science on the basis of philosophical and religious beliefs must be overcome and replaced by positive encouragement of scientific research. (p.617)

Given that philosophical and religious beliefs are an important part of the content of a world view, Basalla is saying in effect that the emergence of an independent science requires a scientifically compatible world view. The people of nonscientific, nontechnological (but modernizing) societies often have world views that are incompatible with scientific thinking. It is not that they are nonrational, but that their rationality based on a different world view results in a nonscientific way of thinking (Horton, 1967). For such a society to develop an independent science, the presuppositional content of the world view of a significant portion of its people must change. This does not necessarily mean developing a scientific world view, but a scientifically compatible world view. The European world view of the 19th Century was influenced by people of letters such as Goethe, Coleridge and Burns (especially the romantic protesters against the age of reason), just as it was influenced by people of science such as Darwin and Maxwell (Randall, 1940). In the late 20th Century, strong traditional cultures in Japan and India coexist with the rising of modern science. Yet in the West, society struggles to escape the scientism promulgated by the like of H.B.S. Haldane:

> until the scientific point of view is generally adopted, our civilization will continue to suffer from a fundamental disharmony. Its material basis is scientific, its intellectual

> framework is pre-scientific. The present state of the world suggests that unless a fairly vigorous attempt is made in the near future to remedy this disharmony, our particular type of civilization will undergo the fate of the cultures of the past. (quoted by Hedrick, 1989, p.332)

The point is, an independent, prosperous science must have cultural support, but does not require scientific hegemony of culture and intellect.

The Scientific World View?

In the final decade of the 20th Century the task of modern education in any society is influenced by the extent of science compatibility within a society's world view. Figure #8 graphically represents world views in modern and pre-modern societies, given the assumption that one can accurately describe a collection of world view variants by the theme *modern*. Consider as examples, the United States and a non-western, modernizing society (assume equal population sizes). The X-axis represents a hypothetical scale of world view compatibility with scientific thinking. The Y-axis represents the hypothetical frequencies of scientifically compatible world views in the two example societies. The implication of Figure #8 is that a primary task of modern education in a modernizing nation is shifting the distribution of world

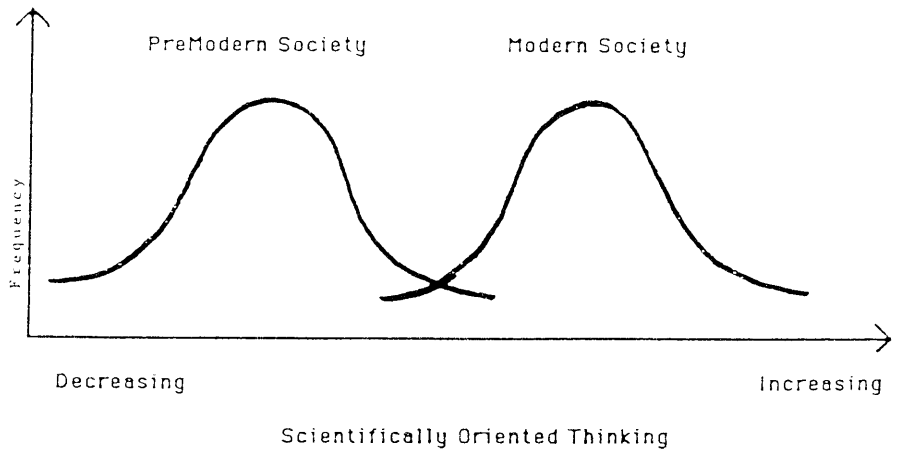

Fig. 8. Frequency of Scientifically Oriented Thinking within Two World Views

view variations sufficiently toward scientific compatibility to allow that society to sustain an independent science (Dart, 1971 & 72).[4,5]

At first one might think that the world view frequency distribution for a modern, scientifically compatible society such as the United States would be drawn with less variation. However, the United States is a pluralistic nation, and is becoming more so. For example, a high school in Houston is reported to have 87 nationalities represented in its student body (Wilson, 1988). Furthermore, it is likely that the historic American subcultures of African-Americans, Native American Indians, and women contribute to the variability depicted in Figure #8, since all are underrepresented among science students and in science-related occupations (Behringer, 1985; Haukoos, 1986; Hueftle, Rakow & Welch, 1983; Malcom, George & Matyas, 1985; Vetter & Babco, 1988).[6] One can surmise that other factors exert a strong influence on the world view variations of these historic subcultures. Contributions to national variability must also come from subcultures transplanted in the United States from nonscientific societies. Furthermore, throughout the whole of American society there is significant interest in decidedly unscientific practices such as astrology (Eve & Harrold, 1986; Good, 1989). Taken together, this suggests world view variation even within what is typically considered a modern, scientific society.

Many would argue that the educational task in the United States the task is to move the distribution center in Figure #8 further to the right, while simultaneously reducing heterogeneity. In other words these advocates wish to see the general character of American thinking become more scientific with fewer occurrences of nonscientific thought. This goal presupposes that for instructional purposes one can describe the contours of a scientific world view.

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[4]Some may wish to argue that *modern* and *western* education can refer to different systems of education on the basis that education for the 21st Century does not have to be western in culture. However, when anyone speaks of *modern* education it usually is in reference to systems adopted from the West. It may be argued that given today's world situation *modern* is by definition *western*. This, however, is changing. In the next few years, one will see Japan emerge as a truly *modern* state that is distinctively *eastern*.

[5]To speak of *modern* education in a modernizing society in no way implies that this is the only type of education in such societies. In all states, even in the West, there exists very rich, traditional education (see for example Hill, 1972). For interesting accounts of the traditional base of what we now term *modern, western* education see Nakosteen (1964) and Riche (1976).

[6]This is not meant to imply an ideology of cultural pluralism that assumes each group to have its own, homogeneous world view, let alone homogeneous, group social and political views, for example. See Chavez (1990).

It further presupposes that this described, scientific world view is in fact best for American society and culture.

One is immediately confronted with a difficult question. What is this thing being called, *the* scientific world view? At the philosophical level there is no clear answer. This is evident from the lively debates in science education over the nature and philosophy of science. Consider for example Martin et al. (1988, 1990) who took to task those who believe science ought to be taught *authentically*. Martin et al. identify the problem. The term *authentic science*, as with most professional jargon, means different things to different people. Different people also have different concepts of *the* scientific world view. The only way to avoid the conclusion that there is actually more than one scientific world view is to employ the distinction between *lived* and *articulated* world views. This distinction allows one to hold that while philosophical, ideological and theological claims, for example, lead people to different articulations of a *scientific* view of the world, these people have in common a subset of *lived* presuppositions necessary for science. If these could be identified they might then be incorporated as goals of instruction, especially early childhood education.

Others, however, view these differences within the scientific establishment as so many variations on a single theme. While accepting the notion that there exists a scientifically important subset of presuppositions within the established scientific world view, they object that science as it is currently viewed by the majority of scientists and taught by the majority of science teachers promulgates a prejudiced view of science, people and the world. These objectors fall into two camps loosely related by a common critique of the Western, mechanistic world view. They find the Western world view to be excessively *pragmatic* because only material achievement is considered significant. They find it excessively *empiricist* because the only reality is physical reality. It is excessively *scientistic* because of the exalted position given to mechanistic understanding. It is *exploitive* because of the callous treatment of nature and humanity for material gain. And finally, the Western world view is *elitist* because the gain is for the few and not the many.[7]

Of the two camps, the feminist camp is the more widely known. The feminist camp specifically charges that science is not only a bastion of male activity, but that the entire edifice of science presupposes male psychology and male dominance. According to Sandra Harding:

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[7]These emphasized adjectives are borrowed from Henryk Skolimowski (1974, p.53) who uses them in his critique of progress as related to a scientific world view.

> [Science] is inextricably connected with specifically masculine...needs and desires. Objectivity vs. subjectivity, the scientist as knowing subject vs. the objects of his inquiry, reason vs. the emotions, mind vs. body - in each case the former has been associated with masculinity and the latter with femininity. In each case it has been claimed that human progress requires the former to dominate the latter. (1986, p.23)

Harding thus wishes to see the complete reconstruction of the extant scientific world view (as she interprets it) in a feminist mode (Coughlin, 1984; Keller, 1985, Harding & O'Barr, 1987).[8]

The second camp, arguably related to the feminist camp (see Perreault, 1979; Bazin, 1982), is the Eastern mysticism camp based on the work of Berkeley physicist Fritjof Capra (1977; also see, Capra & Steenbergen, 1985). Capra observed that although physics has traditionally been known as the "hardest of the 'hard' sciences" (1977, p.21), it is modern physics that leads to mysticism. According to Capra, the Eastern mystical, scientific world view:

> may be characterized by words like 'organic,' 'holistic,' or 'ecological,' since it regards all phenomena in the universe as integral parts of an inseparable, harmonious whole...all things and events...are interrelated and are but different aspects or manifestations of the same ultimate reality...the cosmos is seen as one inseparable reality-forever in motion, alive, organic, spiritual and material at the same time. (1977, pp.21&22)

While Capra's ideas may not be popular in the scientific and educational establishments, they are very appealing to animal rights activists, radical environmentalists, and followers of New Age philosophies. Given the environmental difficulties currently facing society, this view of reality is more likely to gain adherents than lose.

There is a third camp to be consider, though not a camp to be thought of as objectors. This is the camp of theistic realists, or theistic critical realists. This camp does not seek to reconstruct science in some new form, but to support both natural and theological science while at the same time curbing scientism. The eminent Barthian theologian, T.F. Torrance, in a

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[8]For an opposing feminist view, see Margarita Levin (1988).

passage concerning Einstein, commented on the relationship between natural and theological science:

> science is quite unable through demonstration...to provide the basic belief in the objective rationality of the universe or the aspiration toward truth and understanding which it clearly requires. Without profound faith of this kind, which comes from religion and revelation, science would be inconceivable. However, science itself has a religious dimension in which it contributes toward a religious spiritualization of our understanding of life, if only through the humble attitude of mind toward the grandeur of reason incarnate in existence...what is intended here is not that theology should take into its material content ideas derived from natural scientific knowledge...any more than natural science should incorporate into its developing stock of ideas distinctly theological conceptions...what is envisaged here is an exercise in conjoint thinking. (1981, pp.7&8)

On a more personal level, distinguished physicist Carl Friedrich von Weizsacker, discussing what as a youth drew him to science, wrote:

> The experience of such a night cannot be described in words; I can only give the residual thoughts after the memory has faded. God was present, somehow, in the indescribable magnificence of that starry night. Concurrently, I was aware that stars are balls of gas consisting of atoms and obeying the laws of physics. The tension between these two truths must not be unresolvable. But how could they be reconciled? Is it possible to find the reflection of the glory of God also in the laws of physics? (1988, p.1)[9]

Other representatives of this camp are Thorsen (1978), Peacocke (1981, 1986), Jaki (1986), and Ratzsch (1986).[10]

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[9]von Weizsacker was a student and associate of Werner Heisenberg, and from 1979 to 1980, the Director of the Max Plank Institute.

[10]Good sources of material on theistic realism are *Perspectives on Science and Christian Faith*, the journal of the American Scientific Affiliation, and *Zygon*, the journal of the Center for the Advanced Study of Religion and Science.

Practicing Western scientists may be found in all three of these camps. Of more importance for education is that these three camps represent significant portions of Western society that cannot be swept aside with impunity. This is not to say that the views found in these camps are equally valid. Rather, one can persist in speaking of *the* scientific world view only by ignoring the variation both within the science establishment, and also the variation represented by these camps.

Scientifically Compatible World Views

Difficulties with the concept of scientific world view are encountered precisely because any articulation of a scientific world view is a configurationalist or thematic statement, which in fact provides very little information about the people who purportedly hold such views. Nor is much gained by substituting mechanistic for scientific. One still has a monolithic view that glosses over substantial differences, such as the differences between the scientists B.F. Skinner (1971) the mechanic and Fritjof Capra (1982) the mystic; between Carl Sagan (1985) the secularist and John Polkinghorne (1983) the Christian.[11] Furthermore, a monolithic view is meaningless in the face of radically divergent views such as feminist science. Earlier it was commented that one may more profitably refer to scientifically *compatible* world views. Using the logico-structural model of world view it becomes possible to speak of world views that are actually quite different, yet scientifically compatible. In this way of thinking, world view variations can be seen to accommodate divergent scientists such as Sagan and Polkinghorne; as well as to provide a structure for evaluating radical world view claims against the practice of science.

Implicit in the logico-structural position that world view is a composite of seven integrated universal categories, is the possibility of many world views; and even more world view variations or variants, which also vary in degree of scientific compatibility.[12] Consider most any American scientist and most any Indian scientist, such as C.V. Raman.[13] While one may be tempted to say that they both have *the* scientific world view, in fact their world views

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[11]Until 1979, Polkinghorne was a distinguished, mathematical physicist at the University of Cambridge. He is now an Anglican curate.

[12]Configurationalist scholars typically speak of fewer than ten, distinct world views. See for example, Pepper (1942) or Smart (1983).

[13]C. V. Raman was the Indian physicist at the Indian Association for Cultivation of Science, Calcutta, who won the 1928 Nobel Prize in physics for the discovery that bears his name, the Raman Effect (Bhargava & Chakrabarti, 1989).

will be quite different (at both lived and articulated levels). This is illustrated by the frequency distributions in Figures #9 and #10.

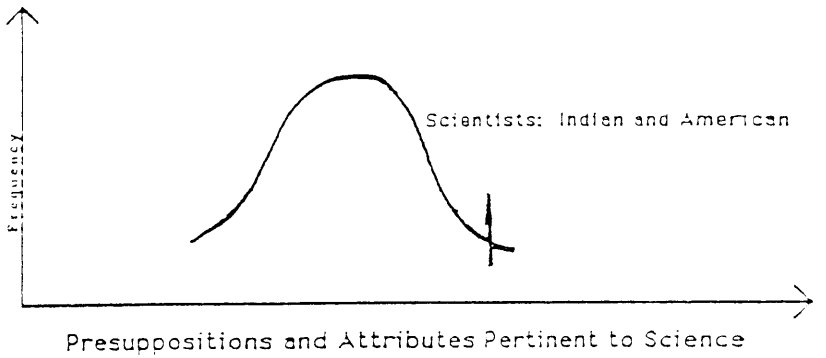

Fig. 9. Frequency of Americans and Indians on a Science World View Scale

Assume for the sake of argument what educators tend to take for granted, that there are world view presuppositions and attributes pertinent to science. Figure #9 depicts what one could reasonably predict a frequency distribution of the general Indian and American populations on a hypothetical measure of these pertinent presuppositions and attributes to look like. The scientists both appear far to the right indicating the presence, in their individual world views, of these science related presuppositions and attributes. This is what one would expect. By this indicator the two scientists are similar, and many would thus say they have *the* scientific world view.

Now consider Figure #10. This is a hypothetical frequency distribution of general American and Indian populations on a hypothetical measure of Eastern presuppositions and attributes. This time, reasonable prediction places the American scientist on the left along with the majority of Americans, scientist or not. While elements of the American scientist's world view may be similar to elements of an Eastern world view, this is a reasonable placement because overall the American scientist is a Westerner. The Indian scientist however, is reasonably placed to the right reflecting an Eastern

background (MacCormac, 1988). It may well be that the Indian scientist's scientific training has changed some of his or her Indian presuppositions. To the extent that this has happened, the Indian scientist may fall more to the left of his or her compatriots in Figure #10.[14] Nevertheless, a significant difference would still remain between the two scientists.

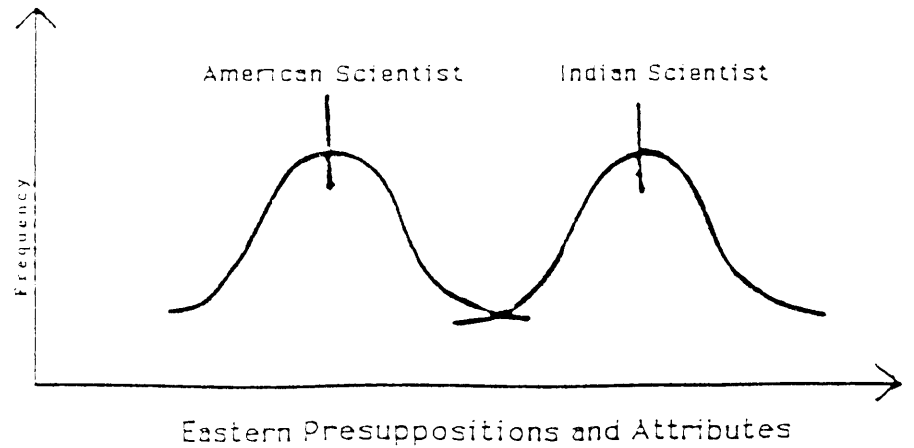

Fig. 10. Frequency of Americans and Indians on an Eastern World View Scale

According to the logico-structural model, a single scientific world view is not to be expected. There will be presuppositional content within the seven, world view universals that is fairly constant across a group of people considered to have a scientific point of view. For example, it is likely that these people hold the NonSelf presupposition:

> that the things and events in the universe occur in consistent patterns that are comprehensible through careful, systematic study. (AAAS, 1989, p.25)

This is content pertinent to the enterprise of science. There will also be

[14]Assuming the rather ethnocentric, but reasonable position that in general western views are more scientifically oriented.

content differences. For example, Indian and American scientists are likely to have quite divergent views on religion, philosophy, and social relationships. Depending on cultural background, differences may be rather large, as is likely between Indian and American scientists. Differences may also be rather small, as is likely between scientists from different American or different Indian subcultures. This kind of differentiation implies that it is more accurate to say that an American scientist has a scientifically compatible *variant* of an American world view. Likewise, an Indian scientist has a scientifically compatible *variant* of an Indian world view. The distinction between world view and world view variation, or variant, of a world view may be likened to the distinction between language and dialect.

Confronting Variation

The Nature of Science: This variation among scientists noted above raises the first in a series of critical questions.

> 1. Given the considerable variation among scientists due to the many cultures in which they live, what are the essential presuppositions and attributes of a scientifically compatible world view?

The universality of patterns in nature has already been given as an example of a presupposition necessary in science. The world view of Collingwood's pathologist provides a second example, this one of a presupposition in the Causality universal necessary for a world view to be scientifically compatible. The presupposition is that all effects, E, have causes, C.[15] This presupposition is modified by an interaction with a presupposition in the Classification universal, i.e., there are different classes of cause. The pathologist undoubtedly recognizes several classes and to these classes he will apply attributes such as *usage*. Because he is a pathologist one can be sure that of the various classes of cause he assumes always to exist, he considers some to be appropriate for science and others not. Eventually this avenue of reasoning leads to an informational level where the pathologist has stored knowledge of specific causes for specific effects, e.g., virus X causes disease Y. This is a much narrower, more defined level of epistemological structure than the level of world view universals. The work on meaningful learning by Novak (1977)

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[15]This understanding of cause and effect is based on *dyadics*, the assumption that in essence there is only one kind of natural event in the world, "the mutual action between two things" (Percy, 1989, p.81). Percy's essay is a good introduction to this aspect of the western, science-influenced world view. Also see the works of Charles Sanders Pierce.

and Ausubel (1963) concerns epistemological structures at this level of an individual's total mental framework. However, a scientifically compatible world view does not require the lower, informational levels (e.g., that virus X causes disease Y). It only requires that presuppositions and attributes be in place so that when specific information is confronted, such as the effects of viruses, the information will be meaningful. In this case, one would say that compatibility requires an appropriate notion of cause.

While the above example speaks of science knowledge, it could as well have been science processes, or what is often called scientific thinking. Briefly, in the universal Relationship, Collingwood's pathologist has presuppositions concerning ways of knowing. These interact with Classification presuppositions resulting in some categories of knowing appropriate for science, and others not. The knowledge that scientific ways of knowing involve empirical observation, theory, and experiment will be related to presuppositions in science pertinent categories.

The nature of science, which is of major interest among science educators, is closely related to this question concerning the presuppositions and attributes of a scientifically compatible world view. Science education research relevant to the nature of science (e.g., Kimball, 1967), relies heavily on works in the philosophy of science. As researchers seek a better understanding of the concept of a scientifically compatible world view, world view theory will require that they become more involved with studies in the history and sociology of science (e.g., Barnes & Edge, 1982), and with feminist and theological studies (e.g., Rosser, 1989, and Polkinghorne, 1983, respectively). Science educators speak of authentic science in the science classroom, and science instruction that model science. Science educators speak of fostering in students a scientific world view, which presumably means the world view of scientists. However, the point of the preceding paragraphs is that scientists drawn from the world over do not comprise a single, homogeneous group of people that can accurately be said to have a single world view. If that is the case, then the goal of authentic science in the classroom means that world view study in science education must include a focus on the world views of scientists *in culture*.[16] Failing to do so means pursuing a scientific outlook *out of context*.[17]

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[16]For example, Hallyn (1990) provides a fascinating account of the heliocentric revolution not from the stand point of scientific history, but from the cultural context in which Copernicus and Kepler lived.

[17]The contextual issue is further addressed on pages 79-87.

The Nature of Students: World view variation is of course relative. The differences between any two American scientists are small, as compared to the differences between an American scientist and an Indian scientist. In comparing two American scientists one realizes that most American scientists were born and raised in America. Most American scientists are white males from middle class backgrounds. Furthermore, most have had their science inclinations developed through years of schooling that involved similar science textbooks and teachers similarly trained (though it must be admitted that the quality of schooling can vary significantly). The point here is not to in any way denigrate the people who are American scientists, but to point out that they comprise a rather homogeneous group relative to scientists world wide. The world views of American scientists are also rather homogeneous, in contrast to the world view variations among all high school and college students. One can reasonably predict that major world view variations stem from racial, ethnic, gender, and religious differences, as well as from economic class, geography, and family-type differences. The fact that students bring these world view variations to the science classroom precipitates two more questions.[18]

2. Can scientifically neutral presuppositions and attributes within student world views be identified?

3. What are the student presuppositions and attributes that actively hinder scientific understanding and science attitudes?

The significance of the three questions is that the answers have the potential to improve educators' understanding of what is and is not a science misconception, of how commonsense theories develop, to improve the definitions of appropriate scientific attitudes and improve attitude research approaches. The potential also exists for a broader, more coherent framework in conceptual studies.

Teacher Variation: Before leaving the discussion of world view variation, it is important to note that variation also exists among teachers. Teacher world view variation, in fact, raises two issues. As alluded to in Chapter 4 (p.55), teachers employ in their teaching a great variety of analogies, metaphors, and

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[18]For concurring positions, see Hawkins & Pea (1987) and Matsui (1989); however, these articles differ in that they define culture quite narrowly. For research relevant to the world view approach advocated here, see Bloom's work on *context of meaning* (In Press) and Solomon's work on the social construction of knowledge (1987 & 89).

explanations. They also make different choices of content. The research in these areas is largely descriptive. However, world view theory focuses attention on teacher cultural context. To again use the analogy of singer and song, it is the study of the singer that allows one to understand the song. As advocated by Campbell (1988) and Goodson & Walker (1988), understanding the teacher's life allows for greater understanding of the teacher's behavior in the classroom.

The second issue concerns the teacher's understanding of science within the cultural context of the teacher, i.e., within the teacher's personal world view variant. In science education there is a rich literature on the nature of science as understood by teachers. The research is generally quantitative such as the widely cited study by Kimball (1967), and also free of any contextual interests. More recent research such as Ledbetter (1987) use the contextually sensitive methods of qualitative research, yet do not pursue the issues of context. While it is of interest to identify teachers' different conceptions of science, understanding why these conceptions make sense to the teachers is of greater importance.

The second issue concerns teacher differential treatment of students. In her study of social class and school knowledge, Anyon wrote:

> When Max Weber and Karl Marx suggested that there were identifiable and socially meaningful differences in the educational knowledge made available to literati and peasants ... they were discussing earlier societies. Recent scholarship in political economy and sociology of knowledge has also argued, however, that in advanced industrial societies such as Canada and the U.S., where the class structure is relatively fluid, students of different social class backgrounds are still likely to be exposed to qualitatively different types if educational knowledge. (1981, p.3)[19]

This allegation is corroborated by a recent article on unintended bias in the science classroom by Contreras and Lee (1990). One would not wish to over extend the claims of world view research, but it is reasonable to suspect that understanding teacher bias will require that teacher behavior be placed in a rather complete context. This context surely includes the teachers' individual world view variations.

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[19]Also see Page's study (1989) of school culture and teachers' perceptions of students.

World View as an Educational Goal

It is implicit in the Basalla model discussed earlier in this chapter that a modern society will seek through education to promote scientific understanding and ways of thinking. It was noted that this objective bears on the issue of world view. The preceding sections, however, warn of the difficulties encountered when one speaks of a scientific world view, let along *the* scientific world view. Nevertheless, it is evident that such language is common in science education. The recent Project 2061 document *Science for All Americans* sponsored by the American Association for the Advancement of Science is a good example. This document contains a brief, cogent section on the nature of science (AAAS, 1989, pp.25-31), which includes a reference to the scientific world view. Admirable philosophical goals? Yes. World view? No, a world view is a totality concept. People live in cultural (geopolitical, sociocultural, economic) context. World view presuppositions important to science are set in a nexus of many presuppositions all having to do with the varied aspects of one's life in cultural context. The philosophical view capsulized by the 1989 AAAS document[20] and generally found in the literature of science education, is the view of a scientific paper, as opposed to the actual world view of a scientist. Basing his comments on the work of Mahoney (1976, 1979) and Mitroff and Mason (1974), Gauld wrote:

> the *real* scientist departs considerably from the picture presented in the science education literature. (1982, p.113, his emphasis)

He later commented that one the basis of evidence presented one could conclude,

> that development of the scientific attitude in students should be eliminated as one of the major goals of science education, and this certainly follows for the attitude as it has been formulated by science educators for the past 60 years. (p.118)

What Gauld called the scientific attitude, others call the scientific world view. The problem, to use Holton's (1952) terminology, is that science education presents science in its *public* form, rather than its *private* form. Or, from the perspective of world view theory, the scientist of the science paper and of science education is a scientist out of cultural context, which is to say a nonperson.

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[20]For other summary pieces on the nature of science, see Gauld (1982); Storer (1966); Barber (1952); Merton (1968, originally published in 1942).

As it has often been done, one can decontextualize science on paper, but not in the flesh. Once the shift is made to a view held by a person, by definition neither science nor any other philosophy or activity can be decontextualized. Whatever a person knows, he or she knows in cultural context. Gauld says it is wrong for educators to mold students in the image of a decontextualized scientist because it is a false image. Furthermore, the myth of a decontextualized science obscures the personal context that an educator brings to the classroom. Gerard Fourez' excellent article on ideology and science teaching (1988) provides a good example. Fourez told of a scientist colleague who insisted "my course is scientific, period." To which Fourez rejoined, "science classes, like every other teaching situation, carry ideas, values, projections, and worldviews" (p.269). Fourez' colleague perhaps did not wish to admit it, but there is no such thing as a course that is "scientific, period."

Consider a more recent example. In a critque of Lawson (1988), Bloom & Borstad (1990) observed that:

> empirical research is being advanced on a *value* premise that is essentially buried. Nowhere does Lawson argue why we should "overthrow" children's alternative conceptions about science and "implant" scientific ideas. (p.400, emphasis added)

Fourez would concur. The perspective from world view concurs. However, in Lawson's rejoinder, he says the reason he did not discuss "why" should be obvious:

> I aim to teach science. Science consists of a set of procedures for acquiring knowledge plus the knowledge that has been acquired. Scientifically valid knowledge is hard to come by. Do Bloom and Borstad really want us to teach invalid knowledge? (1990), p.406)

Given the opportunity, Bloom and Borstad might well respond: It is should be *obvious* that this is not a matter of valid versus invalid knowledge, but of *which* validated knowledge, and thus the significance of the question why.

Evidence of a teacher's context is not difficult to find. It can be seen in Lawson's rejoinder. Or, consider the following passage concerning the strength of scientific explanation:

> what we know of the origin of species from Darwin's work is a triumph of scientific materialism: neither supernatural

> mysteries nor explanations peculiar to biological science are needed; just 'simple' deductive logic, and appropriate empirical verification. Needless to say, the simple logic of Darwin's explanation is the simplicity of genius. (Gough, 1978, p.6)

Like Fourez' colleague and Lawson, this teacher would also say "my course is scientific, period." The teacher's protestations not withstanding, it is clear that Gough's comments extend beyond the pale of science into metaphysics. His very words (e.g., scientific materialism, just simple deductive logic) betray the influence of his personal world view on his understanding of science. Among scientists, some would share his view, but others would not.

Gough and Fourez' colleague hold a common view. They believe they know what it means to have a scientific world view; and, they believe many student world views need to be exchanged for this scientific world view. According to Brunkhorst and Yager:

> students seem to internalize their experiences with the real world. The misconceptions they hold come from real world experiences; such experiences are the basis for their world view, vis-a-vis the world as they have seen or experienced it. When this view is in conflict with science of textbooks and school, students either reject the school science...or play the school game...but retain their experience-based explanations. Science teaching/learning becomes dogma, (something to be accepted without question and/or real understanding). (1986, p.369)

This passage correctly identifies the basis of a student's world view in everyday experience, but it goes on to imply that such a world view is often unsatisfactory. Experience based world views need to be replaced by a school mediated, scientific world view. But what is this replacement view? Is it Gough's scientific materialism? According to Smolicz and Nunan (1975), the school mediated, scientific world view frequently refers to:

> the *anthropocentric view* (man as conqueror and controller of nature through science), the *principle of quantification and demystification* (science as a rational process for obtaining quantitative information about the world), the *positivistic faith* (faith in the continued advance of technology through application of scientific method) and the *analytic ideal* (the assumption that the whole is best understood by a study of its component parts). (quoted in Hodson 1985, p.27)

Nadeau and Desautels (1984), Hodson (1985), and Duschl (1988) all basically concur. Regardless of how students feel about their science instruction, as noted by Brunkhorst and Yager, many students know how to play the school game. They get through a science course by accepting science as dogma, i.e., "something to be accepted without question and/or real understanding" (p.369). It is evident that many students, actually being very wise, fail to find the view point of science, as it is described above, superior to their own personal, experience-based view points. And thus, the National Science Board laments the sorry state of scientific literacy in the U.S. (Good, 1989).

There is little debate that people are well served by a good understanding of science. There is also little debate that the public image of science is in need of repair:

> to say that public support for science ebbs and flows is to misrepresent the depth of popular ambivalence and anxiety about scientists and what they do. When science is not being blamed for threatening the very existence of the globe, it is accused of despoiling nature and dehumanizing mankind with technology. (Gerbner, 1987, p.109)

There is no lasting bliss in ignorance, and so there is no debate that education involves the development, and sometimes the change, of student beliefs. It would be hypocritical if a teacher did not believe his or her beliefs to be essentially correct.[21] What one teaches about photosynthesis is what one *believes* to be true about photosynthesis.[22] Photosynthesis is a specific topic and a benign one at that. The more important issue is a teachers' personal contextualization of science in general, and the sense of science that subsequently infuses the classroom. This issue of contextualization prompts four more critical questions.

4. To what extent is the teacher aware of the context of science being promulgated in his or her classroom?

5. What is the teacher's context, i.e., the beliefs and presuppositions?

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[21]For a good discussion on the ethics of teaching beliefs, see Degenhardt (1986).

[22]The word *true* is not used in the sense of absolute truth, but in the sense that something is valid, essentially correct.

6. To what extent is this context essential for science? (refer to question #1, p.75)

7. What contexts do the students bring to the classroom, and how do these interact with the teacher's context? (refer to questions #3 & 4, pp.77&82)

The teacher, however, who asserts "I teach science and nothing but science!" is contextually blind, and will have no use for these questions. Ledbetter (1987) and Matsui (1989) concur. Power made the same basic point in 1977:

> Teaching and learning must be understood in terms of the values, purposes and perceptions of the participants, rather than in terms of constructs deriving from pre-structures, instrument or psychological theory. (quoted in Solomon, 1987, p.68)

To further clarify the issue of world view and context, consider Figures #11 and #12, which are an attempt to illustrate the factors impinging on the sense-making processes of an individual.[23] Factors are represented by embedded boxes. Since world view is totality concept, in each diagram world view is represented by the most inclusive box. Religion and philosophy are represented by the second most inclusive boxes. Beyond these levels the boxes are of about equal size in deference to the difficulty of determining whether any of these subordinant factors is more inclusive than the others. The sets of boxes form several hierarchial contexts that impinge on the sense-making events represented by bold letters. Notice that in Figure #11, there is nothing that represents science. If this were the representation of a student, a researcher might find that the student's learning of science, for example, is hindered by inadequate conceptions of the relationship of force and motion (e.g., Clement, 1982). Given sufficient self-awareness and gumption, the student could well respond, "Inadequate says who?" The implication being that the student's conceptions of force and motion are inadequate only when removed from the student's personal context.

Of course, it is in everyone's interest that the student gain a scientific understanding of force and motion. At the present the thrust of science education is to displace students' commonsense theories and untutored beliefs

[23]The factors in this illustration are important ones. However, the illustration is hypothetical. There may well be other factors, such as the influence of formal schooling. Also, the relationships of these factors may be quite different from what the illustration suggests.

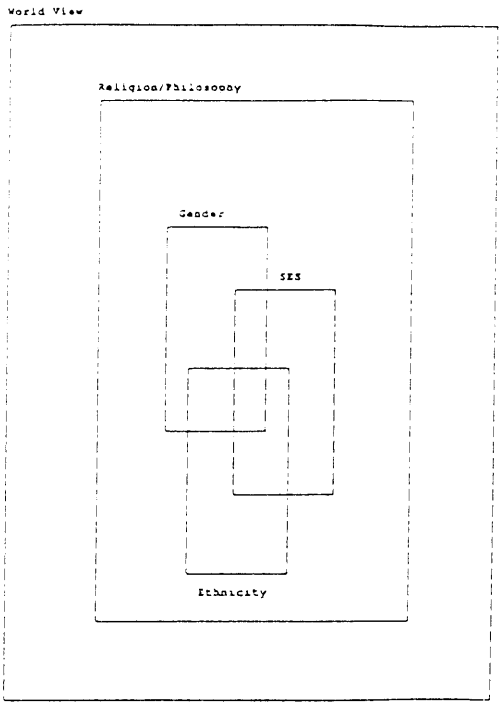

Fig. 11. Contextual Factors Excluding Science

with scientific conceptions. However, while there is evidence that commonsense theories impede science learning (e.g., Novak, 1987), there is no evidence that commonsense views must be removed before science learning can take place. People typically hold multiple, seemingly contradictory views; but the individual has an organization that makes personal sense of apparent contradiction.[24] The point of this discussion is that instead of focusing solely on the student conception, researchers should examine two contextual sets. There is the student's context which supports the student's conceptions, and there is the teacher's context in which instruction is couched. Figure #12 represents the goal of contextually sensitive education. Scientific literacy becomes integrated into the student's world view as an enhancement. To have

[24]Note in Chapter 1 (pp.6&7), the comment by Boas with regard to alleged primitive thinking.

an understanding *of science that allows the promotion of scientific literacy*, however, involves a third contextual set, the contextual set of scientists. One is, thus brought back to the seven critical questions listed above.[25]

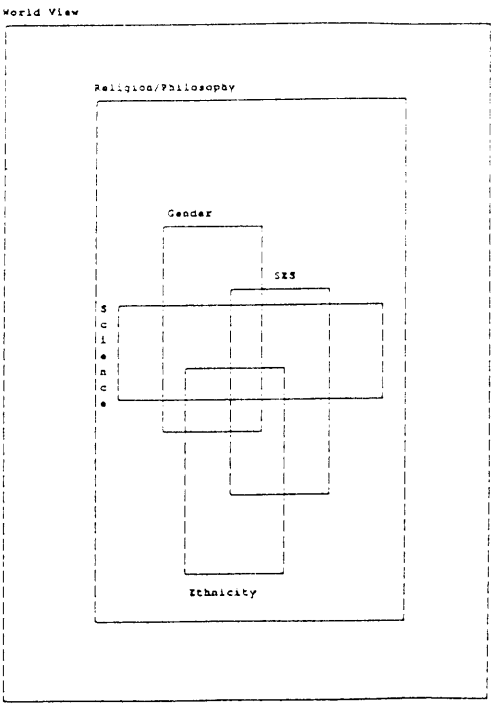

Fig. 12. Contextual Factors Including Science

There is in the literature of science education some fine material on the philosophy of science. Bybee (1990) has recently commented that the trio of Duschl's *Restructuring Science Education* (1990), Martin's *Concepts of Science Education: A Philosophical View* (1972), and Robinson's *The Nature of Science and Science Teaching* (1968) provides an excellent philosophical background for

[25]This assumes that to start with the student's world view was not inherently incompatible with science. Inherent incompatibility, admittedly presents a much more difficult situation. Nevertheless, a contextually sensitive approach would still be in order.

studies in science education. The Project 2061 document (AAAS, 1989) previously noted is also a fine addition to the literature in science education. What is lacking is the socio-cultural dimension. It is to the credit of the science education community that in recent years educators and researchers have engaged in a vigorous reexamination of the goals for science education. The result is newer goals that are more philosophically sound, and are more contextually sensitive. There is a significant, emerging understanding of the importance of viewing science in *social* context. Scientifically literate citizens are ones,

> who understand how science, technology, and society influence one another and who are able to use this knowledge in their everyday decision making. (Koballa, undated, p.33)

To further strengthen this definition of literacy it should be made clear that society includes culture, that science exists in a cultural context, and that there are significant science-*cultural* interactions. Dart has gone so far as to suggest that for some students science should be taught as a "second culture" much the same way that non-English speaking students are taught English as a second language (1972). The second culture approach is a contextually sensitive approach. It suggests that science education should help students see that science is *another* powerful way of viewing the world, and that in certain circumstances it is a necessary way.

Return now to Figure #8, the original point of departure for this lengthy discussion. The American educational task is not necessarily to move the distribution center further to the right, and it is even less the task to reduce heterogeneity. American pluralism is a great source of vitality and attempts at drastically reducing pluralism are likely to be both futile and counter productive.[26] The notion of a scientific world view is inherently ambiguous and ideologically laden, and therefore suspect as a goal of education in a democratic society. However, education can enhance and enrich student world views, in much the same way that learning a second language can be an enriching experience. The task is not so much to change world view as it is to build bridges of understanding between the enterprise of science and the world view variations held by students. To this end an examination of the non-western studies on teaching science as a second culture

[26]Excessive pluralism does create severe problems. In 1990, while the U.S.A. is a pluralistic nation, with but minor exceptions the schools have not yet been confronted with extreme world view diversity. Furthermore, the historical growth of science and the influence that science historically has had on western culture suggests that the process of learning science, even as a second culture, will quite naturally exert an homogenizing influence on student world views.

is perhaps a worthy project. In the meantime, one may actually be thankful that science education as found by Smolicz and Nunan (1975), has not been more successful. One should be glad that not too many students have come to share Darwin's twilight lament.

CHAPTER 6

World View and Science Education Research

> In common with so many others, I used to think that we could get rid of Bantu 'stupidities' by suitable talks on natural science, hygiene, etc., as if natural science could subvert their traditional lore or philosophy. We destroy in this way *their* natural sciences, but their fundamental concepts concerning the universe remain unchanged...(Father Temples, 1959, emphasis added).

It was noted in Chapter 1 that the strength of misconception work is the focus on student epistemological structure and the interest in working from the students knowledge to the objective of instruction. There is, however, an inherent weakness. As Father Temples discovered, students are not stupid. Students generally prefer ideas that make sense to them regardless of what the teacher says.

Application to Misconception Research

The power of the logico-structural model of world view lies in its research utility for the analysis and understanding of world view variation not only where there is a **prima facie** case for such variation, but also within what is usually considered a single world view group, such as the typical American classroom. This is most easily seen in the investigation of students' untutored beliefs, here to fore misconceptions. In a typical piece of research the investigator might explore students' understanding of the concept *ecosystem* by asking students why some organisms consume other organisms in a given pattern or sequence. The investigator typically labels responses such as "It's God's purpose," or "Organisms eat other organisms to preserve their species," as misconceptions (Marek, 1986). The researcher might then attempt to displace the alleged misconceptions by employing Ausubelian cognitive bridges, i.e., the introduction of a lesson using statements intended to connect new material to what the students already know (Ausubel, Novak & Hanesian, 1978). More recent literature argues for the conceptual change approach (Posner et al., 1982), which involves:

> the interaction of new knowledge with existing knowledge in order that the new may be reconciled with the old. The process of reconciliation involves, firstly, dissatisfaction with existing conceptions in the light of new information; secondly, as a consequence of this dissatisfaction, differentiation of existing conceptions, or even the rejection of some in favour of others, that is an exchange of conceptions. In many cases new conceptions may be integrated with existing conceptions, or different conceptions integrated with each other. This requires contiguous ideas in which there is no conflict of meaning or understanding. (Hewson, 1988, p.323)

The meaningful learning and conceptual change models do help, but to date research shows the effects to be limited (e.g., Champagne et al., 1985). Based on world view theory, one can argue that by labeling student beliefs as misconceptions one has accepted an oversimplified and distorted notion of student thinking. Instructional methods thus grounded are inherently flawed.

To return to Hawkin's terminology, the science teacher with respect to student views of the world is confronted with a critical barrier phenomenon:

> the product of the interaction between different sets of intellectual habits or filing systems: those which serve to animate and organize the knowledge or understanding the

> uninitiated bring with them to instruction, and those which inform and direct various fields of contemporary scientific inquiry. (Hills & McAndrews, 1987, p.211)

The conceptual change model attempts to deal with a critical barrier phenomenon by making the dissonance explicit, on the assumption that students will recognize the superiority of the instructed conceptions vis-a-vis their own untutored beliefs or commonsense theories. Hewson (1988) pointed out that the success of this approach requires that three conditions be met: intelligibility, plausibility, and fruitfulness (p.324). And,

> if the student acquires the scientific conceptions, it is because the scientific conceptions are seen to be more powerful and useful in explaining and predicting phenomena. If the student does not acquire the scientific conception, it could be because existing conceptions remain more intelligible, plausible and fruitful for the student. (p.324)[1]

From the perspective of world view theory, the assertion "it could be" is much too mild. Rather, a student does not acquire the scientific conceptions precisely because these are less intelligible, less plausible, and less fruitful from the student's point of view (Driver et al., 1985). Rummelhart and Norman suggested that:

> the learning of a complex topic involves three modes, *accretion* ... addition of new information to the learner's ideas/beliefs about the topic... *restructuring*... the reorganizing of ideas/beliefs about the topic... *tuning* ...refinements resulting from continued use of ideas/beliefs... (Gunstone, 1988, p.87, emphases added)

If students can readily relate science instruction to the untutored beliefs they bring with them to the classroom, approaches such as the conceptual change model should precipitate the *accretion* and *tuning* of knowledge. But what is intended of the conceptual change model is the very thing it is least able to do, i.e., precipitate the restructuring of belief. One may summarize by saying that much of science instruction assumes the very thing it is attempting to

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[1]The exception one may take to Prof. Hewson's comment is that she apparently has made the acquisition of scientific concepts an either/or issue. The concept of world view presented in this monograph, in addition to the specific idea of science as a second culture, implies that the learning of science need not be an either/or issue vis-a-vis other ways of viewing the world.

bring about.[2] From the point of world view theory, Clements (1987) use of anchoring concepts is a more promising instructional approach because it allows a more positive role in learning for student ideas. Clements has achieved a degree on instructional success by identifying ideas that students hold that also can serve as points of attachment for new learning.

Reinterpreting Misconception Data

Reconsider the above example of misconception research in which the researcher investigated students' understanding of the concept *ecosystem* by asking them why some organisms consume other organisms in a given pattern or sequence (Marek, 1986). Responses such as "It's God's purpose," and "Organisms eat other organisms to preserve their species," are considered misconceptions, but are they? These are not the responses of students who after instruction have just plain got it wrong. Assuming that the students have responded sincerely, these responses have the appearance of commonsense. Instead of setting the displacement of the student ideas as the immediate goal, one should try to understand the student beliefs that support student ideas. A world view analysis begins by assuming that student responses are meaningful to the students, if not to the teacher. A logico-structural analysis of the above example suggests that the responses are indicative of epistemological presuppositions within the world view universals NonSelf, Causality, and Classification. For clarification, consider Figure #13 which is adapted from Richard Bube's structural diagram of the universe (1971).[3] This is a convenient way of showing the NonSelf as a composite of categories, or subdomains (all of which are subject to further subdivision). The first two columns contain parallel sets of categories, the first column showing more general terms and the second more specific. The third column shows a corresponding set of intellectual disciplines. The existence of a category in the NonSelf not only makes a particular discipline meaningful, but also the concepts of causality associated with that discipline.

The student who gives "God" as an explanation for a natural phenomenon does so because there exists important theological categories in the student's classification of the NonSelf (though this is not to imply that the student is a self-conscious theologian). One can also assume that the student's

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[2]Hewson's (1988) and Toulmin's (1972) work on the ecological context of knowledge is an avenue that complements well world view theory.

[3]At one time positivists felt that any explanation, whether it was in biology, psychology, or economics, could be reduced to a physical explanation. In a recent article on the subject David Owens argued that while physics has a "certain ontological and causal primacy" this does not give special status to physical explanations (1989, p.59). Also see McDonald (1989).

General Categories	Specific Categories	Intellectual Disciplines
Ultimate	God	Theology/Philosophy
Human	Society	Sociology
	Man/Woman	Anthropology and Psychology
Living but nonhuman	Animals	Zoology
	Plants	Botany
Simple Life	Cell	Biology
Material but nonliving	Nonliving matter	Physics and Chemistry
	Molecules	
	Atoms	
	Elementary Particles	
Nonmaterial	Energy	Origins

Fig. 13 Categorizing the NonSelf

(adapted from Bube, 1971, p.34)

biological categories are relatively weaker. In contrast, biology instruction primarily involves the categories of cell, plant and animal. Other categories in Figure #13 may also be involved on occasion, but certainly not theological categories. In other words, biology instruction is functionally atheistic.

Furthermore, biology textbooks and classroom teachers typically employ a rather restricted definition of cause (Kilbourn, 1974).[4] The teacher

[4]This is of course a generalization. There are science teachers with other views of causation, including religious ones (Dagher & Cossman, 1990). As pointed out in the preceding chapter, such teacher variation invites world view research.

and textbook typically say, one can explain (i.e., give the cause) an event **E** when one knows that event **E** occurs only when the material conditions **C** occur, where the conditions **C** are a restricted set of categories within the NonSelf domain (Ross 1962, p.64). Again, the instruction is functionally atheistic because the restricted set does not include theological categories (Kilbourn, 1974; Proper, Wideen & Ivany, 1988).

The student's use of God as an explanation suggests a significant disjunction between aspects of the student's world view and that which is projected in the classroom (Pines & West, 1986). A natural, inculturated view appears to be at odds with a formal, instructional view. The categories of the NonSelf important to the student are the very ones deliberately shunned in the classroom. In Aristotelian terms, the student's interest is in final causes, not the efficient causes of biology instruction. In this world view analysis the student's response is not at all a misconception, but a meaningful response. The student's response is a commonsense response based on the student's epistemological framework. Thus, one is led to a different view of classroom instructional failure. The conceptual change model for instruction likely will fail because the model provides the *right* answer for the *wrong* question. The model fails to help the student see that there is a significant question for which science instruction is providing the right answer. In this specific case, instruction has not helped the student articulate theological and biological categories in such a way that both become meaningful for the student.

Like the student above, the student who responds, "organisms eat other organisms to preserve their species" is showing an interest in theological or philosophical categories. It may be that unlike the first student, the second student knows that citing God as a causal agent is inappropriate in a science classroom. Nevertheless, lacking sufficient articulation between theological and biological categories, the student gives a meaningful, teleological response, not a biological one. On the other hand, there may be a nontheistic philosophical basis for this response. Further investigation would be required to make a determination. What we can conclude is that, our students may well learn from classroom instruction that big fish eat little fish, but their own world views provide the explanation. This example illustrates the immense difference between understanding and explanation (Strike, 1972). Furthermore, this example is particularly instructive because it implies religious factors, about which science educators are rightfully cautious. The argument from world view does not imply that religious teaching should be introduced in the science classroom. What it argues is that educators' sensitivities notwithstanding, factors such as religion are important aspects of student world views (and for that matter, of teacher world views as well). One cannot ignore these factors and expect that it will make no difference.

Figure #14 summarizes the root analysis of an alleged misconception. The term *misconception* as it is currently used fails to distinguish between two distinct categories. The first category is the relatively simple case of uninformed naivete, inadequate instruction or misinformation that leads to factual misunderstanding. This is the category of true misconception. The student's world view is not the issue, and this is the general assumption in current misconception research. However, world view theory points to a second and much larger category. The alleged misconception can be an explanation logically deduced from a distinctly different world view. Because this conception or belief has intuitive appeal for the student, assimilation of what is considered proper scientific understanding is hindered. Or, a student may have an alternative world view which in principle is capable of assimilating scientific understanding, but does not esteem scientific explanations of physical reality. Thus, the student does not retain them. Third, though a student's alternative world view might not actively hinder science understanding or interest, meaningful learning requires that the science concepts be linked to the student's world view. The failure to establish such links results in the rejection or non-retention of the science concept. In the second category, the student's ideas are not properly called *misconceptions*, for they are logically grounded in the student's view of nature. They are alternative conceptions, only some of which are also *science* misconceptions. One is more correct in referring to them as commonsense ideas or untutored beliefs. In the research literature there are many descriptions of student ideas about physical phenomena. Especially good sources are Driver (1983), Driver et al. (1985), Helm & Novak (1983), and Novak (1987). The events described in these sources are more than mere misconception. To say in what manner these events are related to student world views would require a significant research undertaking. The relationship to world view is not something immediately apparent.

The implications of world view for instruction are significant. Novak (1977, pp.25&26) stated that "meaningful learning occurs when new information is linked with existing concepts" in the learner's cognitive structure. Advance organizers are intended to provide such links. However, the typical advance organizer is a product of a mechanical view of causality and a naturalistic view of the world, and thus would be of limited value for the above students. To be effective, an advance organizer must link instruction with appropriate presuppositions within a student's world view. In the above example the teacher would have to introduce a greater range of classifications, discuss their relations, and the reasons for limiting them in the science classroom. In this example, the suggestion is that science learning as structured by the teacher was hindered because the student found the scientific view unconvincing vis-a-vis his or her personal view. There is no indication, however, that the student's personal view is inherently incompatible with

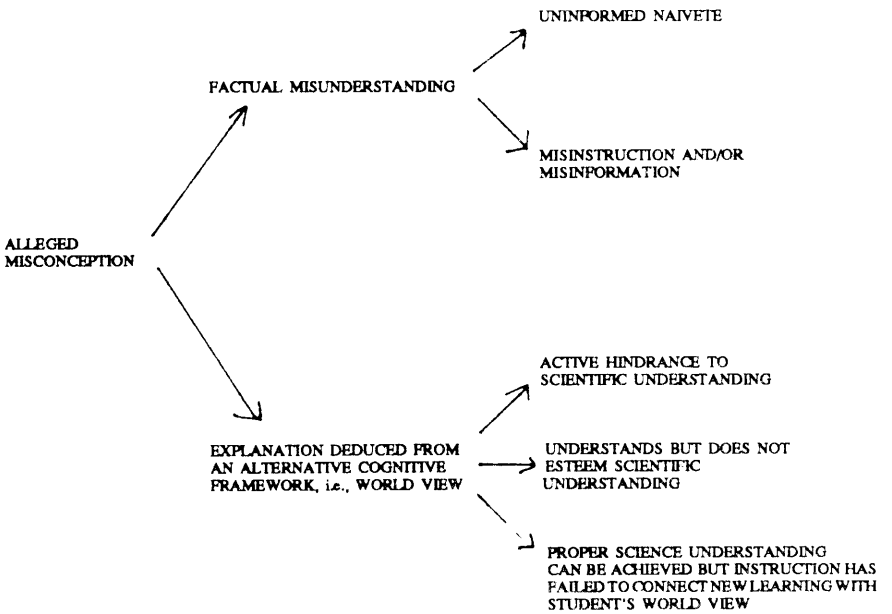

Fig. 14. Root analysis of an Alleged Misconception

science, Thus, the proper instructional goal is not to substitute classifications, but to enrich the student's world view by developing or refining world view classifications.

The above scenario will have to be justified by research. It does have much that is appealing. From world view theory one can infer testable explanations for the answers given by students. One can infer explanations for the ineffectiveness of typical, science instructional strategies. Finally, one can infer that while dissonance strategies do not effectively cope with critical barrier phenomena, strategies that attempt to build deep cognitive bridges reaching back to the students' world view presuppositions will be instructionally more effective. In sum, there is in world view theory significant, potential explanatory power for misconception research generated data.

CHAPTER 6

Validity of the Logico-Structural Model for Science Education Research

It has not been the purpose for this monograph to provide empirical evidence for Kearney's world view model. As stated in Chapter 1, the presentation of logico-structuralism and the marshalling of empirical evidence was the purpose of Kearney's 1984 publication. To this one may add that there is great, commonsense appeal for the six universal categories, Self, NonSelf, Classification, Relationship, Causality, Time, and Space. Could anyone function without such categories? And if world view is what the anthropologists say it is, then the contents of these categories must have some influence on students' behavior in the science classroom. But is this influence of any significance in science education? And if it is, what is the nature and magnitude of this influence?

The significance of world view is inferentially supported by the constructivist epistemology of Novak (1982) and Gowin (1981). Ault et al. wrote:

> several directions in recent science education research point to the importance of understanding the organization of content in cognitive structure...Novak (1982) interprets research over the past several years at Cornell...to favor the view that assimilation of new knowledge is most closely related to the development of cognitive structure...(1984, p.443)

World view is the foundation for cognitive structure as indicated by the position given to world view in Figure #3 (Chapter 2, p.X).[5] Therefore by extrapolation, the evidence noted by Ault et al. for the importance of cognitive structure in learning can be applied to world view. Though this evidence for the significance of world view in science education is clearly circumstantial, it is nonetheless compelling.

Further research on the significance of world view must include investigations of the nature and magnitude of world view influence in science education. However, researchers will pursue these issues only if convinced of the validity of a theory such as logico-structuralism. This validity rests on a theory's power to reinterpret existing research data so that greater, more profound insight into the phenomena is gained. The previous five chapters were intended to support logico-structuralism as just such a theory. The specific arguments were first that one gains insight into student understanding of the world by using a logico-structural world view research approach, vis-a-vis

[5]Also see Figure #1, page 442, in Ault et al. (1984).

misconception, conceptual change, and thematic world view approaches, among others. Second, logico-structuralism is a powerful generator of significant, new avenues of research and methods of research. World view theory must be capable of generating a significant research agenda.

A Research Agenda

The annual end-of-year reviews of science education research (e.g., Koballa et al., 1990) consistently show science educators to be interested in three broad, student oriented, research areas. There is the multifarious research aimed at the direct measurement of student achievement in science, including studies of student conceptions and student attitudes toward science. This research at times involves specific instructional interventions (e.g., Baker, 1988). At other times it stands alone (e.g., Abbott & Lisa-Johnson, 1988). Another major research area is the neo-Piagetian study of student cognitive development, including the development of critical thinking, as it pertains to science education (e.g., Shemesh & Lazarowitz, 1988). And then there are studies of student background factors vis-a-vis science achievement and attitudes (e.g., Haukoos & Chandayat, 1988). These studies primarily employ correlational and survey techniques (e.g., Matsui, 1989).

In addition, there are two fledgling, frequently related areas of research. The use of qualitative research methods marks one of these areas (e.g., Tobin et al., 1990). This research is often guided by the methodological work of Erickson (1986) and Spradley (1979). The other area is comprised of research that focuses on the importance of understanding student ideas and beliefs. In this area Driver's (1983) work is foundational. Other important contributors are Solomon (1989) and Sutton (1989), for example.[6] Bloom's context of meaning research is also included. It is these latter two research areas along with research in cultural anthropology that form the backdrop for the social study of science education in general (e.g., Millar, 1989), and world view research specifically. As will be discussed in the next section, world view research can only be pursued qualitatively. And of course, world view research is inherently about ideas and beliefs, whether ideas and beliefs belonging to students or teachers. The distinctions to bear in mind are that world view research concerns fundamental categories antecedent to knowledge as it is typically studied by science education researchers, and is about knowledge in cultural context.

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[6]The prominent contributors to this research tend to be included in or associated with the Alternative Conception Movement. See for example, Osborne & Freyberg (1985) and Bell (1981).

With this background, one may proceed to consider the investigations suggested by logico-structural, world view theory and the seven critical questions discussed in Chapter 5. What follows is a brief description of six research avenues. The order is intentional. It seems logical that investigations of student world views, teacher world views, and the cultural study of science and scientists can run concurrently, and are prerequisite to the study of world view sensitive instructional procedures, the study of affect, and developmental studies. These six avenues are offered in addition to the several specific studies implied in previous chapters (particularly Chapter 4).

Student World Views: The first research avenue is based on the following critical questions taken from Chapter 5, pages 77 and 83.

> What contexts do students bring to the classroom, and how do these interact with the teacher's context?
>
> Can scientifically neutral presuppositions and attributes within student world views be identified?
>
> What are the student presuppositions and attributes that actively hinder scientific understanding and science attitudes?

The aim of this research avenue is to understand the world views of students. Here student refers to adolescents and adults who may be assumed to have well developed world views, rather than children whose world views are in formative stages. Development issues are not unimportant, but as discussed in Chapter 2, it is questionable that world view formation can be isolated from other aspects of cognitive development in formative stages. There is thus reason to treat cognitive development more holistically as done in context of meaning research (Bloom, In Press). With respect to older students, the logico-structural model provides the researcher with seven basic directions, and many interactions among these basic directions, to follow. Ultimately one would hope to be able to describe the presuppositional contours of student world views, based on the logico-structural model.

Understanding the contour of student world views, however, is only the first half of *understanding* student world views. The second half is placing those world views in cultural context. It bears repeating. American society is a pluralistic society. Its subcultures are defined by language, ethnicity, economic status, gender, and religion. If world view research is to meet its full potential, educators must come to understand how experiences associated

with membership in a cultural subgroup influence and support student world views. For many researchers, the greatest attractiveness of world view research will be the opportunity to bring greater ethnic, gender, and/or religious sensitivity to the classroom.

One approach that researchers might take in the analysis of student world views, based on the mixture of student conceptions shown in Figure #14. This approach involves sorting out true science misconceptions of students from commonsense beliefs, and then attempting to describe world view differences between those students who prefer their own commonsense beliefs and those that more readily adopt formal scientific understanding. Bearing in mind the Driver et al. (1985) finding that students often do not employ scientific criteria for coherence of ideas, one would seek to understand the role that commonsense ideas play in an individual's ordinary life. In other words, if students do not require a scientific sense of coherence and unity, what is it that makes a commonsense belief commonsense? This question brings the researcher to the issue of context. What is the life a student like and how do life events influence his or her thinking?

The weakness of this approach is that it will not likely yield a broad picture of student world views. It is likely to yield but a snapshot of the presuppositions the researcher *believes* to be related to the science conception under study. For example, if a researcher studies student views concerning force, the researcher will first have to fight the tendency to study the student views in relation to scientific conceptions. Instead, the proper objective is to understand student views of force as they relate to students' culturally based, general understanding of how the world works. Even then, a persistent focus on force alone obscures the context in which student ideas about force are held.

The broader, context sensitive picture comes by focusing first on two or three world view categories and their interrelationships (e.g., Cobern et al., 1990). From this point, two corollary research avenues emerge. One avenue is the second half of student world view research mentioned above, i.e., placing those world views in cultural context. The second avenue involves the examination of how student culture interacts with the culture of science as presented in the classroom. What one anticipates is that understanding how the science classroom culture interacts with the cultures of students will enable researchers to better understand conceptual change and attitude development.

An area of research related to the analysis of student world views is the area of cross-cultural and international research. Although cross-cultural research can degenerate into odious comparisons providing bragging rights for the groups that come out on top and political leverage for the also rans, it

also can stimulate informative discussions on the role of culture in education. It has been argued that science education is culturally determined, something difficult to see clearly from within a culture. In principal, international studies involving nations with distinctly different national cultures, such as an African nation and a Western nation, can shed light on the cultural artifacts in the two national science education programs. Furthermore, what the African researcher Hewson has said about science, can be applied to science education:

> rather than continuing to encourage the West to donate scientific knowledge and skills to developing countries, a different approach might usefully be taken. Critical dialogue between the West and the developing countries could promote conceptual change of the knowledge bases of both, and allow for the emergence of a new type of science that is effective in meeting specific problems at a range of levels in developing countries, and possibly in the West as well. (1988, p.317)

The type of comparative cultural study envisioned here involves a dialogue about student world views in two cultures and how those cultures attempt to teach science. Again, the purpose is to illuminate cultural artifacts in education that may or may not be necessary, artifacts that may indeed be damaging. Additionally, this type of research reflects a critical reality. Science and technology transcend national boundaries, and thus neither these nor science education are uniquely Western phenomena any more.

The Culture of Science: The second major research avenue is the cultural analysis of science for the purpose of answering the following critical question (taken from Chapter 5, page 75).

> Given the considerable variation among scientists due to the many cultures in which they live, what are the essential presuppositions and attributes of a scientifically compatible world view?

It was noted earlier that Robinson (1968), Martin (1972), and Duschl (1990) are foundational in science education. These texts provide the *internal* perspective on science in reference to science education. The culture of science, however, includes an *external* perspective. Take for example, Fernand Hallyn's (1990) reconsideration of Copernicus, Kepler, and heliocentrism. Instead of a decontextualized account of an historical event in science, Hallyn places heliocentrism in the fabric of 16th Century European culture. As summarized by his translator:

> Hallyn contends that during this period closely related notions of harmony, symmetry and proportion informed cosmology, music theory and the representation of the human body. (Hallyn, 1990)

Hallyn uses Charles Sanders Pierce's concept of *abduction*, commenting that:

> It is true that factual connections sometimes furnish at least explanations for the appearance of a new hypothesis: the observation of new phenomena, the development of new techniques ... But generally speaking, the establishment of a new hypothesis remains an enigmatic moment. (1990, pp.7&8)

Standard accounts in the history of science speak to the factual connections. But it is in culture that one begins to understand the enigmatic. John Greene takes a similar approach to the historical study of evolution (1961 & 81), in stark contrast to Mayr's account in *The Growth of Biological Thought* (1982).[7]

It is thus fair to ask how closely the image of science and scientists presented in science education fits with the actuality of science and scientists. One may find that at times educators repeat the proof-texting error of logical positivists, that is, the error of constructing a rational view of science and only then looking at actual science for examples to prove their case. Later philosophers and historians examined actual historical science and actual current laboratory practices and came away with a much different view of scientists and the scientific endeavor (e.g., Spiegel-Rosing & Price, 1977). This type of research spawned the social study of science which is both the study of the social interactions among scientists, and the study of science in its economic, political, and general cultural contexts.[8] Researchers in this field have taken great interest in what scientific publications *do not* say, i.e.,

> what is shared with their audience and does not need saying, or what is simply not asked by the audience, is also relevant

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[7]For other research examples that examine, in varying degrees, the external, social history of science, see Thomas' *Man and the Natural World* (1984); Merchant's *The Death of Nature: Women, Ecology, and the Scientific Revolution* (1983); and Mathias' *Science and Society, 1600-1900* (1972).

[8]This is a relatively recent field which came into its own with the first meeting of the Society for Social Studies of Science in 1976. One of the classic texts in this field is Robert Merton's "Science, Technology and Society in Seventeenth-Century England" (1938). For an excellent introduction to the social study of science see Barnes & Edge (1982).

> to interpreting them, and we have no assurances that when they were silent they might not also be presupposing things we do not share with them (Turner 1989, p.371).

As a result of the research in this field many of the unfortunate myths concerning science and scientists, such as the positivist *iceman* image of scientists involved in a totally objective endeavor, have been debunked. Stephen Brush (1974) has already remarked, tongue in cheek, that where students are concerned educators may wish to give the history of science an **X** rating; and so it may be with the social study of science. The point is that by examining the research in the social study of science educators can develop a better understanding of the world view variations among scientists and what it means to have a scientifically compatible world view. To name only a few, there are successful scientists among the ranks of women, African-Americans, Christians, and non-westerners as well as from white, male Americans. What do these people have in common that allows them to value and successfully participate in the scientific enterprize? That should be the understanding that informs classroom practice. And it bears repeating, the goal is not to identify *the* definitive scientific world view, but to determine the necessary and sufficient aspects of a scientifically compatible world view.

Teacher World Views: Associated with the above avenues of research is the social study of science teaching, something that M.F.D. Young advocated in 1974. Given the teacher's central role in the classroom, it is reasonable to form the initial hypothesis that classroom culture is primarily a function of teacher world view. Thus, the critical questions are (see Chapter 5, pages 82&83):

> To what extent is the teacher aware of the context of science being promulgated in his or her classroom?
>
> What is the teacher's context, i.e., the beliefs and presuppositions?
>
> To what extent is this context essential for science?

As discussed in Chapter 5, teachers do not teach science, *pure and simple.* Teachers bring a context to the classroom and they teach from that context. Science teachers do not come to the classroom with a universal, generic scientific world view. The cultural analysis of science and defining the parameters of a scientifically compatible world view, as mentioned above, will inevitably involve researchers in the problem of distinguishing between *lived*

and *articulated* world views. Given a decent education in science, there is every reason to believe that teachers will come to the classroom with logico-structurally related presuppositions and attributes of importance to science. These will not be hermetically sealed off from the teacher's total world view, but will be an integrated part of his or her world view. These will not be decontextualized in the classroom. For example, a teacher may foster in the classroom a view of the world that allows the Heisenberg uncertainty principle to be meaningful for students. That same teacher's articulated view of science may include an extrapolation from the physical phenomenon of sub-atomic uncertainty to philosophical and ideological uncertainty. This articulated view of science is by no means essential to science, and yet because it is important to the teacher it becomes part of what is presented in the classroom as *the* scientific world view. This may occur explicitly or in the hidden curriculum. As stated before, one must be concerned about the inaccurate portrayal of science in education (Gauld, 1987). One must also be concerned about potential mismatches between teacher and student points of view. According to Yager & Kahle (1982):

> Only a few studies have explored how the characteristics of teachers and of students mix to produce various classroom climates and also how these climates influence the learning and attitudes of *diverse students*. (p.526, emphasis added)

A vital item then on any world view research agenda must be classroom culture, or climate as in the above quote. This specifically means the clarification of how teachers articulate a view of science within their own world views, the effect of teacher world view on curricular decisions, and the impact of teacher world views on students.

The next three research avenues are in varying degrees dependent upon the findings of the above research avenues. The critical questions involved in these avenues are the questions of student world views and classroom interaction.

Research on Instruction: The fourth avenue of world view research speaks to activities in the science classroom. Already some writers have implied that science education should be used to influence students' world views (e.g., Proper, Wideen & Ivany, 1988). The theory of world view implies that in the short time span of a typical classroom setting attempts at influencing student world views are not likely to be successful. Indeed, evidence exists that the classroom setting does not appreciably influence student views on the nature of science (e.g., see Lederman, 1986; Lederman & Zeidler, 1986), which should be an easier task than influencing world view. What can reasonably

be predicted is that influence will only be achieved over a long period of time; and that influence aimed at enhancing or further articulating students' world views is more likely to be successful than attempts at overt change.

There is, however, a more practical and ultimately more important issue. Is it possible, and if so is it feasible, to develop effective world view-informed, instructional strategies and materials? In other words, one is asking how knowledge of student world views can be used to help teachers provide more effective classroom instruction. In this research the investigator is trying to develop instructional strategies that are both compatible with the cultures of students, and effective in meeting society's goals for science education. As mentioned previously, some type of *second culture* approach has significant appeal.

Emotion and Affect: The fifth avenue of research involves a relatively underdeveloped area in science education research, i.e., the role of affect or emotion in science learning and attitude development. Unfortunately the distinction between rational and irrational aspects of learning is not clear (West & Pines, 1983; Strike & Posner, 1983). Nevertheless, Novak has written recently that an,

> emerging trend in the psychology of learning is greater emphasis on the role of feelings or emotion in learning, and the interplay between an individual's self-concept and choice of learning strategies and/or domains of science. (1989)

Bloom (In Press) concurs. He asserts that emotion is an aspect of *context of meaning*. A researcher wishing to approach the issue of affect from a world view perspective would be well advised to focus attention on the Self-Relationship-NonSelf structure. As noted earlier, the West has traditionally separated nature and the individual. Gillispie (1960) argued that Galileo further divided the two by distinguishing *size, figure, number, and motion as objective*, primary qualities, while reducing color and taste, for example, to the status of *subjective*, secondary qualities. It was also mentioned earlier, that there is evidence that this is a peculiarly masculine, Western point of view. Logico-structural informed research would investigate the presuppositions of Self, about nature, and about people's relationship with nature in an effort to understand the epistemological foundation for emotions related to science achievement and attitude.

Developmental Research: The final research avenue to be discussed here, though one would hope that other researchers will add to this world view agenda, involves the question of development. It has been argued by Novak (1982) that the data resulting from a Piagetian research paradigm can better be

explained by the constructivist epistemological paradigms of theorists such as David Ausubel. That may well be the case, but it is also possible that some Piagetian research may profitably be redirected by a world view theory such as logico-structuralism. Susan Buck-Morss noted that while Piaget rejected ideologies of biological racism, a universal application of Piaget's developmental theory,

> cannot account for the frequent chronological 'lag' in test performance of non-Western samples and the fact that members of some cultures never 'reach' certain levels of logical operations. (1975, p.261)

Thus, there is a subtle, racist implication. Perhaps placing developmental theory within the framework of world view theory would circumvent this difficulty.

The Methodology of World View Research

Preliminary Issues: Research methodology is a crucial issue, and it is essential to remind oneself that methodology must proceed from a clear understanding of the research questions. A world view investigator might study student concepts of *animal*, not vis-a-vis *animal* as a science concept, but as a concept in cultural context. The researcher chooses a topic such as *animal* because it is a topic of importance in science education; and, in principal, understanding cultural context will work to improve science education. At the risk of overstatement, bear in mind that the distinctiveness of world view research concerns fundamental categories antecedent to knowledge as it is typically studied by science education researchers, and is about knowledge in cultural context.

Having been reminded of the research focus, one must consider the problems involved with presupposition recognition. How do you know one when you see one? If a presupposition is a variety of belief, how can the two be distinguished? As mentioned at the end of Chapter 3, perhaps the best guide was provided by Jones (1972, p.83). He suggested that there are five distinctions between world view presuppositions and ordinary belief. These are paraphrased below using the terminology of this monograph rather than Jones'.

1. The uses one has for particular beliefs tends to be obvious, while the uses for presuppositions are much more subtle.

2. Generally, beliefs are easily verbalized by

an individual. Presuppositions are very difficult to verbalize and impossible when subconscious. An objective in world view research is to verbalize infrequently verbalized presuppositions.

3. Beliefs can be taught with relative ease and often are taught through formal instruction. Presuppositions are learned informally over a much larger span of time.

4. Presuppositions are both resilient and tenacious. They flex, but do not easily change fundamentally. Beliefs are much more readily modified or changed.

5. Beliefs tend to be about specifics and are invoked only on specific, relevant occasions. The influence of presuppositions is continuous, but very subtle.

While helpful, it is obvious that these distinctions are not going to be clear in every case. It is important not to get bogged down in semantic hair-splitting. One should apply these distinctions for getting at fundamental levels of belief, recognizing that distinguishing among those presuppositions and beliefs that hover about an interface is probably not all that important.

The Collection of Data: Perhaps the best place for anyone to begin a search for world view research methodology is with the literature of cultural anthropology.[9] What one finds is that the research is ethnographic, in that it focuses on people in their life-settings, their culture, what they do and believe, and why they do and believe those things. The research of cultural anthropology is also found to be qualitative in that it focuses on what life events are like and the context of those events, rather than on quantitative measures of those events.[10] The distinctiveness of qualitative methodology is its contextual sensitivity. According to Smith (1987):

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[9]For different examples see Farris & Glenn (1976); Agar (1980); Hvitfeldt (1986). Also see classic ethnographies, such as Evans-Pritchard (1940) and Chagnon (1968).

[10]For an argument, similarly based on world view theory, for the use of qualitiative methods in science education research, see Roberts (1982).

> Qualitative researchers reject the notion of universal, context-free generalizations. Learning to solve word problems in arithmetic, for example, is not something that occurs in isolated, antiseptic, laboratory-like settings; rather, it takes place in contexts of human and institutional purposes, prior learning and teaching, and the presence of others; it is facilitated or inhibited by material and physical resources; it involves personal and interpersonal histories, and the like. (p.175)

In recent years qualitative research has gained popularity in the general field of education (e.g., Erickson, 1986), as well as in the specific field of science education (e.g., Tobin et al., 1990). Smith (1987) pointed out that there is considerable disagreement among researchers as to what properly constitutes qualitative research. Some researchers hold to quite exclusive definitions. However, Smith persuasively argued that there are at least four distinct, research approaches that can properly be called qualitative. The approach most commonly employed in science education research is an interpretive approach. There are also artistic approaches, systematic approachers, and theory-driven approaches. Given its origin in anthropology and the fact that it is inherently a totality concept, it is reasonable to assume world view investigations will be done qualitatively, after one fashion or another.

Having raised the subject of qualitative research, the subordinant issue of *etic* and *emic* approaches, terms originated by the missionary and linguistic theoretician Kenneth Pike (1954), must also be discussed. Boas exemplifies the emic tradition:

> If it is our serious purpose to understand the thoughts of a people the whole analysis of experience must be based on their concepts, not ours. (1943, p.314)

On the other hand:

> Eticists believe that the conceptual categories of cultural reality must be determined by the researchers, based on their identification of the causes of cultural phenomena. (Shimahara, 1988, p.81)

In both education and cultural anthropology it is the emic perspective that researchers most frequently take. There are however, categories that one knows to be of interest in a broad range of socio-cultural settings. The family, for example. Regardless of cultural group, an anthropologist will want to know how families are defined, organized, and they functions. Family is

an etic category, even though the researcher will seek data on the family from an emic perspective. In a similar fashion, logico-structuralism provides a set of etic categories of interest over many settings. However, the researcher will no doubt pursue emic perspectives on Self, NonSelf, Causation, etc. The point is for the researcher to avoid a contrived either/or situation with regard to etic and emic perspectives. The concepts are most profitably use when used as complements.

World view research makes use of grounded theory (Glaser & Strauss, 1967). Essentially, investigators *read back* (Jones, 1961) from naturalistic observational data or interview data to explanatory or descriptive categories. This task can be facilitated by constructing Vee maps (Ault et al., 1984), where palcement on the Vee is determined by fit of data with the distinctions of presuppositions listed earlier. The categories inferred from the qualitative data are hypotheses. According to Hutchinson (1988):

> The task is to discover and conceptualize the essence of specific interactional processes. The resulting [grounded] theory provides a new way of understanding the social situations from which the theory was generated. (p.124)

In world view research the inferred hypotheses are possible world view presuppositions. One would expect predictions to be deduced from the hypothesized presuppositions and subsequently tested by further observations. Inferences must find warrant in the source of the data and method of data collection (Lythcott & Duschl, 1990). Validity will mainly be conceded based on the cogency with which warrant is argued in published presentations of the research.

As to specific methods, there are no world view research manuals. this monograph cannot change that, but can offer examples of important ideas and literature. Smith's comment about qualitative methods fits what one finds in the literature of cultural anthropology with respect to world view:

> methods are used inventively and tailored to the situation. In many cases, multiple methods are employed, and the findings of alternative methods are played off against each other. (1987, p.175)

One is likely to use interview methods currently employed in the study of student thinking. For example, the Osborne & Freyberg (1985) Interview-About-Instances (IAI) technique can be adapted for world view research. Consider a current investigation on gender differences with respect to fundamental views of the natural world (Cobern et al., 1990). This research

with college students, which asks about presuppositions in a particular domain of the NonSelf, began with the collection of free expository responses to a question about nature. The researchers examined the data for categories that might be used to organize the data. Following Jones' (1972) suggestion that categories be dichotomous, they found the data to support four categories:

Aesthetic/Materialistic
Sacred/Profane
Conservative/Exploitive
Chaotic/Orderly

In subsequent research an IAI interview technique was adapted to include these categories. The IAI instances became a set of photographs depicting scenes from the natural world. College students were asked to respond to these photographs by offering unrestricted comments, and by responding to statements about the photographs, where the statements were derived from the above categories. From the interview data the researchers will attempt to draw inferences concerning the students fundamental views about the natural world (Cobern, 1990).

As another example consider a preliminary study based on the deduction that world view variation implies that different types of causal explanation will be unequally acceptable among different students, i.e., that students will have differing composites of causal presuppositions (Cobern, 1989). This study involved the development of an instrument for detecting the hypothesized world view variations in the Causal universal. The instrument, referred to as the Test of Preferred Explanations (TOPE), is a paper-and-pen instrument largely comprised of fictional episodes each followed by two explanations of different type (see Figure #15). The explanations were classed either as more scientifically compatible or less scientifically compatible, where scientific compatibility was determined by philosophic analysis. The strategy in this investigation was to *read back* from the TOPE scores to possible causal presuppositions. Although this work is still in progress the early indication is that first year college students bring to class a variety of views with regard to what constitutes a compelling explanation, and that this variation may well be an important factor in science education. However, this study suffered from methodological flaws, and furthermore, the researchers quickly learned that the paper-and-pen format obscured significant contextual information. It is mentioned here because the idea of using fictitious scenarios, including events and various types of explanations, has considerable potential for use in IAI interviews. In addition to data on what types of explanations students prefer, interviews would provide a wealth of data concerning student understanding of explanations, and the reasons they employ in arriving at a preference.

Just as Smith (1987) has commented about qualitative research in general, world view research requires innovative techniques such as the fictitious episodes used in the research described above, as well as other methods found in the literature of anthropology. In addition to these sources there are research methods in the education literature that can be adapted for world view

Senario

Occasionally when entering a room for the first time one gets the distinct impression that he has been there before. This impression can be very strong and disturbing, and all the more because one is sure that he has not ever seen the room before. There seems to be two reasonable explanations for this phenomenon:

A.

This is an example of deja vu which is something almost all of us experience from time to time. It is remembering a place you had never been to before or an object or person you have never seen before. This phenomenon is a reminder of the vast complexity of the human mind, a complexity of which we understand very little. What we understand least is the capacity of the mind to perceive things outside the range of our basic physical senses.

B.

The human brain is a complex electro-chemical computer. Although for the most part it functions faultlessly there are occasional lapses. The above is such a case. After the first glimpse of the room there is an instantaneous functional lapse and recovery. The lapse causes the initial glimpse to be separated from the current perception of the room. The result is that the initial glimpse becomes like a memory. One is deceived into thinking that he has seen the room before.

Fig. 15. Scenario with Fictitious Explanations

use. The Dart and Pradham mapping technique has potential for use in studying presuppositions in the Space universal of students. As mentioned in Chapter 4, these researchers, interested in readiness to understand and use scientific abstractions, compared maps showing home and school drawn by American and Nepalese students (Dart and Pradham, 1967; Dart, 1971; also see McCormack, 1988). Another technique with potential for wider use has

students respond to illustrations. Osborne and Gilbert (1980) used this method to explore students basic understanding of force. A good source of potential techniques can be found in White (1979) which describes various methods for exploring students' cognitive structures. Also, see Millar (1989).

The above examples pertain primarily to research with students, though some of the techniques could be adapted for use with teachers. Techniques such as IAI interviews are recommended because the recording of data on students in naturalistic settings, such as a classroom, is unlikely to provide sufficient data on which to base inferences about student presuppositions in several categories. Teachers, however, occupy a much more observable position in the classroom via lectures, interpersonal communications with students, choices of content and activities. Thus, world view research pertaining to teachers can make significant use of techniques such as classroom videotaping. In earlier comments on the Dagher & Cossman (1990) study, it was however, pointed out that teacher interviews must accompany classroom observation if one is to obtain an understanding of the contexts teachers bring to the classroom. This context is the essential second half of world view research.

Until the previous sentence, the focus thus far has been the first half of world view research, i.e., investigating what people believe about the world. Context is the second, *but no lesser*, half as mentioned in Chapter 2. Contextual research, however, requires a caveat emptor or two. Gender, religious, ethnicity factors among students will draw contextual research. The existence of such factors does not support an ideology of cultural pluralism that asserts a distinct, homogenous world view for each group. One should expect significant intra-subculture variations. Secondly, the understanding of context will not lead to any kind of one-to-one correspondence between cultural factors and beliefs about the world. Cultural understanding provides general understanding of an individual's thoughts and actions.

To do context research is really to do biography (e.g., Campbell, 1988; Goodson & Walker, 1988). Factual data can be obtained from school records or surveys. But to build a picture of a student's or teacher's culture requires interviewing where a person (or possibly a small group) has the chance to freely talk about: his or her family and friends, where the person lives, what is watched on television, what is talked about in casual conversation, what her or she thinks about school, and many other questions. By itself, this would be time consuming research. Coupled with the first half of world view research, the total time required is extensive. If the subject is student world view, the time required increases to the point that a serious problem is posed for most researchers. One way of handling this is to involve teachers as cooperating researchers (see e.g., Tobin et al., 1989). On a day

to day basis, teachers have far more access to students for interviews than do university researchers. Many teachers also enjoy a rapport with their students that would greatly facilitate the task of obtaining life-history data. Furthermore, with proper training there are no methodological reasons for not having teachers participate as research interviewers and interpreters.

In concluding, it is important to note that qualitative, interview methodology is not without its difficulties; and experienced researchers who write about qualitative methodology should not be ignored. Smith (1987) offers several points on what good qualitative research must include. Lythcott & Duschl (1990) point out the centrality of warrant, an issue overlooked in some research. Bell et al. (1985) offers guidelines for conducting interviews. These are experience based guidelines intended to help other researchers avoid methodological errors. The anthropologist Paul Roth has recently written on *Ethnography without Tears* (1989), in which he speaks to Clifford Geertz' comment, "we have met the unreliable narrator...and he is us" (quoted in Roth, 1989, p.555). Roth's article is followed by a series of editorial comments from distinguished anthropologists. The article and comments together provide an informative discussion on issues surrounding the collection, interpretation, and public presentation of ethnographic data.

CHAPTER 7

Concluding Remarks

> But what is meant by the word *explain*? We accept something as an explanation when it shows how an unexplained fact fits into the world as we already understand it. Explanation is related to the framework of understanding we inhabit, the firm structure of beliefs we never question, our picture of how things really are. Explanation puts a strange thing into a place where it fits and is no longer strange. (Newbigin, 1986, p.22)

People live in a rich experiential world brought to them by their senses. But the data of one's senses is an amorphous mass of confusion until interpreted by one's world view. Peter Berger argued in his book *The Heretical Imperative* (1979) that with one exception a people's world view provides a special *plausibility structure* of ideas, activities and values which

allows one to gauge the plausibility of any belief or assertion.[1] For example in a Muslim nation such as Iran the notion of state/religion separation is quite strange because it conflicts with the plausibility structure of an Islamic world view. Berger further stated that the original notion of a *heretic* was someone who decided things for himself or herself instead of employing society's plausibility structure. Societies around the globe have these plausibility structures, and in past times the West also had its plausibility structures. The exception today is the modern West. According to Berger, the rule of the day is that everyone decides for him or herself. In other words, Westerners are all under an *heretical imperative.*

Perhaps not. The theologian Lesslie Newbigin (1986) while essentially agreeing with Berger's critique of the West, argues that Western culture has been so influenced by positivistic notions of science that the Western plausibility structure has become *the facts* (what might also be referred to as naturalism or secular humanism). A distinctive feature of the modern West is that Westerners have divided off the public world of facts from the private world of opinions, beliefs and emotions. Thus, Newbigin argues that Westerners do decide for themselves, but the decisions in the public world are based on *the facts.* It is heretical to do other wise. In the private world, however, one is without a plausibility structure and thus under Berger's heretical imperative.

Together, Newbigin and Berger provide an interesting assessment of Western culture and society. Others are persuaded that there are in fact several world view variants in Western culture, and thus, several plausibility structures. There is reason to agree with Newbigin that science has had and continues to have a powerful influence on the West, and that for many Westerners *the facts* indeed do represent a plausibility structure. For many others however, plausibility is grounded in theism, monism, perhaps even nihilism and hedonism. Westerners have significant similarities within their world views, and most find it appropriate to speak of a Western world view. Still, there are equally important differences.

One can argue that naturalism is the plausibility structure of science education. Furthermore, it can reasonably be asserted that educators typically presume that students in the science classroom also operate within this structure. Unfortunately, American classrooms are filled with heretics operating within other plausibility structures. They are recognized by their alleged *misconceptions*:

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[1]For further study see Berger's *The Sacred Canopy* (1969) and Sire's *The Universe Next Door* (1976).

> Talk of misconceptions...carries with it the suggestion that something has been botched or bungled, or that something has gone amiss...And there is often the further implication that the student is the culprit: that he or she is the one who has gotten something wrong...There is more to error than meets the eye. (Hills, 1989, p.174)

Indeed, there is more than meets the eye. A study of world views will reveal that young children in the classroom are in the process of world view and plausibility structure formation; and school systems certainly do not provide the principal, let alone the sole, influence upon this formative process. Older children, on the other hand, may come to class with well developed world views. Still, the school was not likely the principal formative agent. There is, therefore, little reason to expect that typical science instruction with its presumed plausibility structure will show "how an unexplained fact fits into the world as [the students] *already* understand it (Newbigin, p.22, emphasis added).

World view theory argues first for an understanding of the world as students understand it. If successful science instruction for all is an important American educational goal, ignoring the legitimate variations among people cannot continue. World view theory argues secondly for the close examination of the plausibility structure assumed necessary for science and science education. There is cause for some doubt about this structure given that historically science has been viewed quite differently; and because this structure does not adequately account for the world view variations among scientists and other educated individuals around the globe today.

Heretofore the researcher in science education has lacked a sufficiently powerful, theoretical tool for investigating the merit of these arguments. The value of logico-structuralism is that it provides for this need. The theoretical composite of Self, NonSelf, Classification, Relationship, Causality, Time and Space focuses the researcher's attention on the complexity of world view, and yet the categories themselves provide access to that complexity. And while the composite nature of the model makes it less likely that the researcher will oversimplify the notion of world view, one can still speak of world view unity (e.g., a theistic or naturalistic world view) based on salient presuppositions within the seven universal categories.

As a beginning several research questions have been posed and a research agenda suggested. One may be concerned, however, that immersion in one's own world view blinds a person to both the existence and value of world view variations among others. For this problem, the research of non-westerners who necessarily must deal with science as a second culture can be

of help. A second concern is that researchers be not dismayed by the complexity of world view and the early, overly simplistic approaches to world view study. For this there is help in the literature of cultural anthropology. Ultimately, however, the value of world view theory as a research framework in science education rests on its integrating effectiveness and on the fruitfulness of the research directed by fundamental questions generated by the theory.

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